Vol. 13, No. 2, pp. 255-267, 2023 DOI: 10.23960/jpp.v13.i2.202309

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849

http://jurnal.fkip.unila.ac.id/index.php/jpp/

A Comparison of Students' Mathematical Communication Ability taught by Contextual Teaching and Learning versus Problem Based Learning

Khoirunnisa Nasution* & Slamet Suyanto

Department of Research & Evaluation, Universitas Negeri Yogyakarta, Indonesia

*Corresponding email: khoirunnisanasution.2019@students.uny.ac.id

Received: 17 December 2022 *Accepted: 08 March 2023* *Published: 10 March 2023*

Abstract: A Comparison of Students' Mathematical Communication Ability taught by Contextual Teaching and Learning versus Problem Based Learning. Objective: This study aims to compare mathematical communication skills taught by Contextual Teaching and Learning (CTL) and Problem Based Learning (PBL) for 7th grade junior high school students. **Methods:** This quasi-experimental research with two-group pretest and posttest design was carried out on 26 students in the CTL group and 28 students in the PBL group who has chosen by simple random sampling. Ten questions of a math essay test consisting of 5 pretest and 5 posttest questions which accommodated the mathematical communication indicators were applied to the two groups. Data was analyzed using simple descriptive statistical test and t-test. **Findings:** This study proved that the PBL improved students' mathematical communication ability more effective than the CTL model. **Conclusion:** PBL can be considered to be applied in the classrooms to improve mathematical communication ability.

Keywords: mathematical communication ability, contextual teaching and learning, problem based learning.

Abstrak: Perbandingan Kemampuan Komunikasi Matematis Siswa yang diajar dengan Contextual Teaching and Learning versus Problem Based Learning. ***Tujuan:*** *Penelitian ini bertujuan untuk membandingkan kemampuan komunikasi matematis siswa dengan menggunakan Contextual Teaching and Learning (CTL) dan Problem Based Learning (PBL) pada siswa SMP kelas 7.* ***Metode:*** *Penelitian kuasi eksperimen dengan desain two-group pretest and posttest design ini dilakukan terhadap 26 siswa kelompok CTL dan 28 siswa kelompok PBL yang dipilih secara simple random sampling. Sepuluh soal tes esai matematika yang terdiri atas 5 soal pretest dan 5 soal posttest yang mengakomodir indikator komunikasi matematis diberikan pada dua kelompok tersebut. Data dianalisis dengan menggunakan uji statistik deskriptif sederhana dan uji-t.* ***Temuan:*** *Penelitian ini menunjukkan bahwa kemampuan komunikasi matematis siswa yang menggunakan model PBL secara signifikan lebih efektif dibandingkan dengan model CTL.* ***Kesimpulan:*** *PBL dapat dipertimbangkan untuk diterapkan di dalam kelas guna meningkatkan kemampuan komunikasi matematis.*

Kata kunci: *kemampuan komunikasi matematis, pembelajaran kontekstual, pembelajaran berbasis masalah.*

To cite this article:

Nasution, K., & Suyanto, S. (2023). Comparison of Students' Mathematical Communication Ability taught by Contextual Teaching and Learning and Problem Based Learning. *Jurnal Pendidikan Progresif*, *13*(2), 255-267. doi: 10.23960/jpp.v13.i2.202309.

INTRODUCTION

Mathematics is a science that has a significant role in developing modern technology from time to time. The National Research Council (NRC) of the United States explains the importance of mathematics in the following statement: "Mathematics is the key to opportunity." Recognizing how important math is, the Undang-Undang RI No. 23/2003 says that math is one of the subjects that all primary and secondary school students must take. The National Council of Teachers of Mathematics (NCTM, 2000) says that the most important things to learn about math are understanding mathematical concepts, communicating mathematical ideas, making mathematical connections, reasoning and solving problems, and having a positive attitude and interest in math. Mathematical communication is essential for students to have a deep understanding of the subject and be able to solve problems (Rohid & Rusmawati, 2019; Lim & Chew, 2007). Mathematics communication skills are very important for students to learn how to solve mathematical problems using sound reasoning (Tinungki, 2015; Palinussa et al., 2021). Based on this, learning to talk about math is an important part of math and math education.

Mathematical communication can be interpreted as the ability of students to express ideas with symbols, tables, diagrams, or the use of media to solve mathematical problems (Qohar & Sumarmo, 2013; Putri et al., 2020). It contains mathematical material that students learn, such as concepts, formulas, and problem-solving strategies. Sahenk (2010) states that the parties involved in communication events in the classroom environment are teachers and students. The method of transferring the message can be oral or written. Hartina et al. (2019) state that mathematical communication is a crucial mathematical skill. According to The Intended Learning Outcomes by Gardenia et al. (2021), mathematical communication can express mathematical ideas coherently to friends, teachers, and others through written and spoken language. It means that with mathematical communication, the teacher can better understand the student's ability to interpret and express their understanding of their learning concepts. However, mathematics education in Indonesia still needs to meet expectations. Supported by the results of studies in the Program for International Student Assessment (PISA), the average score of mathematical achievement in Indonesia in 2018 amounted to 379. This value has decreased compared to the average 2015 PISA mathematics learning achievement score of 386. Of course, students' low learning achievement has many factors, for example, teacher-centered learning activities, while students tend to be passive. Another factor is applying conventional learning models, lecture methods, questions and answers, and homework assignments (Al-Tabany, 2014). Such a teaching system causes students to refrain from participating in learning activities, so it is feared that students would not improve their mathematics learning activities to improve aspects of thinking or independent analysis. In fact, the more students participate in mathematics lessons, the more it increases student achievement (Wawan & Retnawati, 2022).

When faced with math problems on exams, only a few students can solve them because they only receive the lessons given but need to know how to use the knowledge they have acquired. Students need help determining what first steps to take from the information contained in the test. The information received is not modeled in mathematical form by notations, pictures, graphs, or algebra. Students need help if asked by the teacher to explain again, mathematically, in the design of language or mathematical symbols. It shows the need for mathematical communication skills in students. One of the ways that can be performed to improve students' mathematical

communication skills is by applying a learning model that is appropriate and relevant to be used up by the teacher. The implementation of an effective learning model can increase student grades (Ndia, Solihatin, & Syahrial, 2020; Reigeluth & Carr-Chellman, 2009). Accordingly, one of the efforts that can be applied is the context-based teaching and learning (CTL) model, such as the results of research conducted by Sukma et al. (2022), which stated that there was a significant influence from the application of CTL on students' mathematical communication. Research conducted by Firmansyah et al. (2018) also states that the CTL learning model influences students' mathematical communication skills. Nurmala (2018) states that using CTL can improve student learning outcomes in mathematics. The Washington State Consortium developed CTL for Contextual Teaching and Learning, which involved 11 colleges, 20 schools, and institutions engaged in education in the United States.

Howey (2001) defines CTL as learning that enables a learning process in which students use their understanding and academic abilities in various contexts inside and outside of school to solve simulated or actual problems, either individually or collectively. Elaine (2014) said CTL is a system that stimulates the brain to compose patterns that convey meaning. Furthermore, Elaine (2014) states that CTL is a learning system compatible with the brain that produces sense by connecting academic content with the context of students' daily lives. So, CTL is an effort to make students active in pumping their abilities without losing benefits because students try to learn concepts and apply and relate them to the real world. Mulyasa (Rustam, 2016) said contextual teaching and learning is a learning concept that emphasizes the linkages between the world of learning materials and students in real life so that students can connect and apply competency learning outcomes in everyday life. CTL helps teachers relate the material they teach to students' real-world situations and encourages students to make connections between the knowledge they have and its application in their daily lives. In the CTL approach in this context, students need to understand the meaning of learning, the benefits of learning, and how to achieve it. Here students will find that what is learned is helpful for later life, so it will make students positioned as themselves who need a provision that is useful for later life and students will try to reach it (Pangemanan, 2020). So it can be understood that CTL is a learning approach that emphasizes full student involvement in discovering the material being studied and relating it to real life situations to encourage students to apply it in real life. CTL has seven main components or syntax, and teachers must develop constructivism, inquiry, asking, learning communities, modeling, reflection, and authentic assessment (Al-Tabany, 2014; Pangemanan, 2020). CTL is a learning model that can help teachers relate the subject matter to real life and motivate them to connect knowledge and its application to family members, citizens, and the workforce (Majid, 2014). CTL has more advantages for students. CTL increases the motivation of students to write, encourages increased participation in writing class, determines the topic and main idea of writing, develops their writing, helps solve problems, and prepares ways for students to be involved in a discussion and interact with their friends, helping students to summarize the learning (Triningsih, dkk, 2014).

Besides CTL, problem-based learning (PBL) is a learning model that can affect students' mathematical communication skills. PBL positively and significantly affects mathematical communication skills (Kodariyati & Astuti, 2016). PBL can improve students' mathematical communication by applying problem-based learning models, posing contextual problems based on real-world problems, and providing

guidelines for implementing mathematical communication steps on tests (Duskri, Maidiyah, Risnawati, & Ilham, 2017). This is also in line with the results of research conducted by Marbun & Simamora (2022), which state that there is a positive and significant influence of the PBL model on students' mathematical communication skills. PBL was first implemented in the Medical Faculty of McMaster University in Canada in 1970.

PBL is a learning approach that uses real-world problems as a context for students to learn about critical thinking and problem-solving skills and acquire essential knowledge and concepts from the subject matter. PBL is one of the learning models mainly designed to develop students' critical thinking, problem-solving, and intellectual skills; help them learn the roles of adults with experience through natural and stimulating situations; and help them become independent learners (Arends, 2008). Ibrahim and Nur in Rusman (2010) state that PBL stimulates students' high-level thinking in real-world problem-oriented situations, including how to learn. Duch (2001) stated that PBL is a learning model that exposes students to the challenge of "learning to learn." Students actively work together in groups to find solutions to real-world problems. This problem is a reference for students to formulate, analyze, and solve it.

Furthermore, Duch (2001) stated that this model intended to develop students to think critically and analytically and find and use appropriate learning resources. Tan (2003) argues that PBL is an innovation in learning because, in PBL, students' thinking abilities are optimized through a systematic group or teamwork process to empower, hone, test, and develop their thinking skills on an ongoing basis. The application of PBL is: a) Orientate students with a contextual problem; b) Organize students for research by helping students define and organize learning tasks related to the problem; c) Direct students to solve the problem, by motivating the student to find precise information, to carry out the experiment, and to seek explanation and solution; d) Improve and present the result of the solving problem; e) Analyze and evaluate the process and outcome of problem-solving (Hendriana, Johanto, & Sumarmo, 2018). Problem-based teaching is an efficient approach to teaching higher-order thinking processes. This learning helps students process information already in their minds and organize their knowledge about the social world and its surroundings. This learning is suitable for developing students' ability to think critically and analytically and to find and use appropriate learning resources. Based on the explanation above, the authors tried to compare students' mathematical communication abilities with the CTL and PBL models in class VII Mts Al-Ittihadiyah. To find out the comparison of students' mathematical communication skills taught using CTL or PBL. This study aims to compare problem-based learning to other ways of teaching and learning math, like contextual teaching and learning. This study is expected to serve as a comparison or alternative in choosing the most suitable learning model to teach students communication skills.

METHODS

This research was conducted in class VII MTs al-Ittihadiyah Medan which consists of 7 classes with a total of 178 students. The sampling system used is simple random sampling. A total of 54 students with two experimental groups, namely experimental group 1 with details of 26 students and experimental group 2 with 28 students, in this study did not use a control class to save time.

This study uses a quantitative research method with a quasi-experimental approach because the sample is not randomly selected

but consists of classes made by the school. The research design used was a two-group pretest and posttest design. The pre-test was conducted to determine students' initial mathematical communication skills. Then both classes were given treatment. After that, a post-test was given to find out which learning model most influenced students' mathematical communication skills. Which is described as follows.

Table 1. Two-group pretest and posttest design

Class	Pretest	Treatment	Postest
Experiment 1	T_1	CTL	T_2
Experiment 2	T_1	PBL	T_2

Both classes were given the test twice, namely before and after treatment. The test given before the treatment (T1) is called the Pretest and the test given after the treatment (T2) is called the Posttest. Both classes received different treatment, the experimental class 1 was given the CTL treatment which was adjusted to the CTL principles according to Pangemanan (2020) and the experimental class 2 was given the PBL which was adjusted to the PBL principles according to Hendriana, Johanto, & Sumarmo (2018).

The instrument or test used to obtain data in this study is a math essay test on rectangular material that has been adapted to students' mathematical communication indicators. The indicators of students' mathematical communication used in this study are: a) presenting and visualizing mathematical problems in the form of images and interpreting the images and presenting them in mathematical ideas (drawing), b) explaining/writing mathematical problems in written form using mathematical rules, and c) being able to read and interpret data into mathematical models or in other words express mathematical ideas (mathematical expression) (Ansari, 2016; Kusumah, Kustiawati, & Herman, 2020; Rustam & Ramlan, 2017). Can be summarized Table 2.

Table 2. Indicator of mathematical communication ability

Mathematical Communication Ability Indicators	Material Indicator
1. Capable to present and visualize mathematical problems in figurs and interpret figures, and present them in mathematical ideas (*drawing*)	a. Capable to determine the properties of a quadrilateral. b. Capable to calculate the area and perimeter of a rectangle.
2. Capable to explain or write mathematical problems in written form using mathematical rules	Capable to solve problems related to quadrilaterals.
3. Capable read and interpret data into mathematical models or in other words express mathematical ideas (*mathematical expression*).	Capable to solve problems related to quadrilaterals and apply them to everyday life

The instrument consisted of five pre-test questions and five post-test questions given to the CTL and PBL classes. The researcher makes the test through a validation process by experts then tests it for estimated reliability. The average validity coefficient of the entire set of instruments is 0.81 which is calculated using the Aiken formula indicating that the instrument is included in the high

validity category and can be used. The results of trials conducted on 49 students obtained an estimated reliability of Cronbach's alpha of 0.67, which means that the instrument is reliable or can be used to measure students' mathematical communication abilities.

The data analysis technique used was the paired sample t-test to determine whether there was a difference in the mean pretest and posttest given in each class. The hypothesis and decision making are as follows:

1. H_a accepted, if the value of Sig.(2-tailed) < 0.05, it means that there is an average difference between the pre-test and post-test results. Furthermore, an independent sample t-test will be conducted to compare the average results of the students' mathematical communication skills in the CTL and PBL classes. The hypothesis and decision making are as follows:
2. H_a accepted, if the value of Sig.(2-tailed) < 0.05, which means there is a difference in the average students' mathematical communication skills (post-test) between the CTL class and the PBL class.

RESULTS AND DISCUSSION

Communication skills are very important in supporting the learning process. Communication skills play an essential role in learning mathematics, especially in students' training in developing argumentation abilities. Good communication will undoubtedly run better according to the goals if it is supported by a good learning model, especially in learning mathematics. One thing that worries the researchers is the problem-based learning model and teaching and learning in a real-world setting. This is because mathematics is limited to describing something and presenting something as accurate or directly contextual. Of course, this has an impact on students or teachers. Therefore, comparing the two learning models, especially in terms of communication skills, is very important. From the results of the analysis in Table 3 and others, it presents the results of a study of how the two learning models impact communication skills.

Table 3 is the result of the paired sample t-test analysis, which shows that there is no difference in the mean pre-test and post-test given in each class. It can be seen that the Sig. (2-tailed) in the CTL class and the PBL class 0.00 < 0.05, then H_{a1} is accepted, and there is a mean difference between the pre-test and post-test results. It can be said that there are differences in mathematical communication abilities before and after treatment.

Table 3. Paired sample t-test

		Mean	Std. Dev	T	df	Sig. (2-tailed)
Pair 1	Pre-test CTL – Post-test CTL	-16.61538	10.66987	-7.940	25	.000
Pair 2	Pre-test PBL – Post-test PBL	-28.21429	15.20077	-9.822	27	.000

Table 4. Independent sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Mathematical Communication Skill	Equal variances assumed	3.428	.070	-2.373	52	.021
	Equal variances not assumed			-2.337	42.264	.024

Table 4 shows a significant difference in students' average mathematical communication skills in the CTL and PBL classes after being given treatment. We have seen from Sig. > 0.05. Furthermore, in "Equal variances assumed," it is known that the Sig (2-tailed) value is 0.021 <0.05, then H_{a2} is accepted, so there is a significant difference in the average students' mathematical communication skills.

Table 5. Normality test

	Class	Statistic	df	Sig.
Ngain Persen	CTL	.965	26	.503
	PBL	.962	28	.390

Before analyzing the independent sample t-test for the N-Gain Score, an analysis of the normality assumption test was conducted, which is presented in Table 5. Based on Table 5 above, it is known that the significance value (Sig.) The CTL class is 0.503, and the PBL class is 0.390. Because both types have a Sig value of more than 0.05, the data used in this study are normally distributed.

Furthermore, in Table 6, it is known that the significance value (Sig) of Levene's Test for Equality of Variances is 0.390 > 0.05, so the N-Gain data variance (%) for both classes is the same or homogeneous. Thus, the independent sample t-test for the N-Gain Score is shown in Sig. Table of Equal variances assumptions. Based on this, Sig. (2-tailed) of 0.003 < 0.05 meaning that the PBL model effectively improves students' mathematical communication skills. Based on Table 6, it can be seen that the CTL model is less effective in enhancing students' mathematical communication skills. Meanwhile, the PBL model is considered quite effective in improving students' mathematical communication.

Table 6. Independent sample t-test for n-gain score

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Ngain_Persen	Equal variances assumed	.752	.390	-3.069	52	.003
	Equal variances not assumed			-3.048	48.736	.004

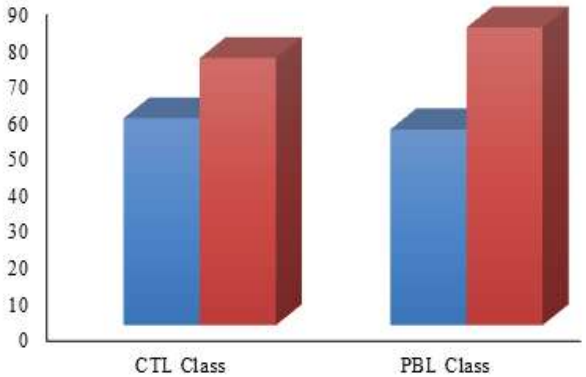

Figure 1. Pre-test and post-test average score graph of ctl and pbl classes

Figure 1 shows the average value of the pretest and posttest of students' mathematical communication skills. In Figure 1, it can be seen that the pretest mean score of the CTL class is better than the PBL class, which means that the initial ability of the CTL class students is better than the PBL class before being treated. Furthermore, after being given treatment or students' posttest scores in the CTL class, the mean score of students was lower than in the PBL class, which means that the PBL model was better than the CTL model to improve students' mathematical communication skills. However, after being given the treatment or the CTL model and the PBL model applied in the learning process, the results of the students 'mathematical communication skills applied using the PBL model were higher than the students' mathematical communication skills applied using the CTL model. In PBL students will be actively involved in the problem-solving process. Students analyze and evaluate their own thinking processes and make conclusions from the knowledge that has been found with guidance and instructions from teachers or friends in the form of leading questions (Aufa, Saragih, & Minarni, 2016).

Figure 2. N-Gain score

Then the N-Gain Score in the CTL class is 40.84 or rounded to 40.84%, which means that the CTL model is less effective in improving students' mathematical communication skills. Meanwhile, PBL is 61.00 or rounded to 61%, which means that the PBL model effectively improves students' mathematical communication skills.

The following will outline the components involved in this study, specifically the learning aspects to develop students' mathematical communication skills, in light of the research findings (Table 3 & Figure 1). This study shows that students who teach math using a problem-based approach do better at communicating math than those taught using traditional methods. Students exposed to math problems as part of their education can better explain their ideas and solve problems than those taught the same material more traditionally. Theoretically, there are benefits to problem-based learning that aren't present in formal education. In light of these learning features, problem-based instruction's benefits are outlined below.

Problem-based learning (PBL) structures are taught around student and societal needs. There are no easy solutions to the difficulties presented to the students. For questions or issues to be considered legitimate by Nufus &

Mursalin (2020), they must also be clear, straightforward, and relevant to the course material. Hadi (2005) says that the main things about math education in Indonesia so far are teacher-centered learning, the lecture method, and students writing down lessons in notebooks. None of these things are typical of traditional education. Second, if students are going to find real answers to the challenges given, the teacher needs to encourage them to do their research. In conventional classrooms, the instructor guides or facilitates the student's education. Student discussion groups are developed as a third method of collaboration in problem-based learning. Students work in small groups to solve real-world situations that test their math and communication skills. Students in a problem-based learning environment work together to solve problems with their peers as they learn. College kids confer with one another and their professors, and they ask each other questions. Contrarily, in a traditional classroom setting, students take on the role of receivers, gleaning all relevant information from the instructor and collaborating on problem-solving in small groups. Pupils' worldviews are shaped only by the teacher since the students can only learn the procedures by watching the teacher. Therefore, pupils play a minor role in the educational process.

Research findings based on the results of data analysis show that the PBL model is better than the CTL model in improving students' mathematical communication skills with 5 indicators of mathematical communication. This can be seen from the average initial ability value of the CTL class which is higher than the PBL class before being given treatment. However, after being given treatment, the average value of students' mathematical communication skills taught using the PBL class was higher than the CTL class. In PBL, it involves groups of students being encouraged to communicate with their friends. Likewise, when presenting the results of groups of students are required to communicate with friends and teachers. Therefore, PBL is an alternative learning that can be applied in class to improve students' mathematical communication skills. This is in accordance with the results of research conducted by Madhavia's (2020) research, which states that the PBL model influences students' mathematical communication skills, and Anim & Saragih's (2019) which states there are differences in mathematical communication skills of students taught using a PBL model compared to students who are taught using the 9% CTL model. Marbun & Simamora's (2022) research states there is a positive and significant effect between problem-based learning models on students' mathematical communication skills.

Even after solving the problem or difficulty, there is always reduce. For this reason, the Problem Based Learning model in this study will help or encourage students to always think positively that every time there is a problem, there will always be convenience or lessons that can be obtained. That is the PBL learning step which involves groups of students who are encouraged to communicate with their friends. Likewise when presenting the results groups of students are required to communicate with friends and teachers. Therefore, PBL is an alternative learning that can be applied in class to improve students' mathematical communication skills.

■ CONCLUSIONS

Based on the findings of the researchers and the results of the data analysis above, it can be concluded that the CTL learning model is considered less effective in improving students 'mathematical communication skills. In

contrast, the PBL learning model is considered quite effective in enhancing students' mathematical communication skills. Therefore, the PBL model is better than the CTL model in improving students' mathematical communication skills. Researchers recommend the use of the PBL learning model rather than the CTL learning model in improving students' mathematical communication skills. However, it is also not closed to other learning models that are considered suitable for improving students' mathematical communication skills.

■ REFERENCES

Ahdhianto, E., & Santi, N. N. (2020). The effect of metacognitive-based contextual learning model on fifth-grade students' problem-solving and mathematical communication skills. *European Journal of Educational Research*, *9*(2), 753-764. https://doi.org/10.12973/eu-jer.9.2.753

Al-Tabany, T. I. B. (2014). *Mendesain model pembelajaran inovatif, progresif, dan kontekstual*. [Designing innovative, progressive and contextual learning models]. Prena Media Grup.

Anim, A., & Saragih, E. M. (2019). Differences of students' mathematical communication skills through contextual teaching learning with problem based learning model. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *9*(1), 83–90. https://doi.org/10.30998/formatif.v9i1.3186

Ansari, B. I. (2016). *Komunikasi matematik strategi berfikir dan manajemen belajar* [Mathematical communication thinking strategy and learning management]. Penerbit PeNA.

Arends, R. I. (2008). Learning to teach. The McGraw-Hill Campanies.

Aufa, M., Saragih, S., & Minarni, A. (2016). Development of learning devices through problem based learning model based on the context of aceh cultural to improve mathematical communication skills and social skills of SMPN 1. *Journal of Education and Practice*, *7*(24), 232–248.

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). The power of problem-based learning: a practical "how to" for teaching undergraduate. Stylus Publishing.

Duskri, M., Maidiyah, E., Risnawati, R., & Ilham, S. (2017). *Penerapan model problem based learning untuk meningkatkan kemampuan komunikasi matematis dalam pemecahan masalah di kelas ix-6 smpn 8 banda aceh* [Application of the problem based learning model to improve mathematical communication skills in solving problems in class Ix-6 SMPN 8 Banda Aceh]. *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika*, *1*(1), 75. http://dx.doi.org/10.22373/jppm.v1i1.1734

Elaine, B. J. (2014). Contextual teaching and learning. Mizan.

Firmansyah, A., Hasanuddin, H., & Nelson, Z. (2018). *Pengaruh model pembelajaran contextual teaching and learning terhadap kemampuan komunikasi matematis berdasarkan pengetahuan awal siswa* [The Effect of Contextual Teaching and Learning Learning Model on Mathematical Communication Ability Based on Students' Prior Knowledge]. *JURING Journal for Research in Mathematics Learning*, *1*(1), 01. http://dx.doi.org/10.24014/juring.v1i1.4772

Gardenia, N., Herman, T., Juandi, D., Dahlan, T., & Kandaga, T. (2021, March). Analysis of mathematical communication skills of class 8 students on two-variable

linear equation systems (SPLDV) concept. In *Journal of Physics: Conference Series* (Vol. 1806, No. 1, p. 012073). IOP Publishing. https://doi.org/10.1088/1742-6596/1806/1/012073

Hadi, S. (2005). *Pendidikan matematika realistik dan implementasinya [*Realistic mathematics education and its implementation*]* . Banjarmasin : Tulip.

Hartinah, S., Suherman, S., Syazali, M., Efendi, H., Junaidi, R., Jermsittiparsert, K., & Rofiqul, U. M. A. M. (2019). Probing-prompting based on ethnomathematics learning model: The effect on mathematical communication skill. *Journal for the Education of Gifted Young Scientists*, *7*(4), 799-814. https://doi.org/10.17478/jegys.574275

Hendriana, H., Johanto, T., & Sumarmo, U. (2018). The role of problem-based learning to improve students' mathematical problem-solving ability and self confidence. *Journal on Mathematics Education*, *9*(2), 291–299. https://doi.org/10.22342/jme.9.2.5394.291-300

Howey, K. R. (2001). Distance teaching for hight and adult education. Croon Helm.

Kodariyati, L., & Astuti, B. (2016). *Pengaruh model pbl terhadap kemampuan komunikasi dan pemecahan masalah matematika siswa kelas v sd* [The influence of the pbl model on the communication and problem solving skills of students of grade v elementary school]. *DoubleClick: Jurnal Prima Edukasia*, *4*(1), 93. https://doi.org/10.21831/jpe.v4i1.7713

Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The effect of geogebra in three-dimensional geometry learning on students' mathematical communication ability. *International Journal of Instruction*, *13*(2), 895–908. https://doi.org/10.29333/iji.2020.13260a

Lim, C. S., & Chew, C. M. (2007, December). Mathematical communication in malaysian bilingual classrooms. In *APEC-Tsukuba International Conference: Innovation of classroom teaching and learning through lesson study-focusing on mathematical communication* (pp. 9-14).

Madhavia, P., Murni, A., & Saragih, S. (2020). *Pengaruh model problem based learning terhadap kemampuan komunikasi matematis siswa kelas vii smp kabupaten kuantan singingi* [The influence of the problem based learning model on the mathematical communication skills of class vii students of middle school in kuantan singingi regency]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *04*(02). https://doi.org/10.31004/cendekia.v4i2.357

Majid, A. (2014). *Strategi pembelajaran*. PT Remaja Rosdakarya.

Marbun, Y. M. R., & Simamora, R. (2022). *Pengaruh model pembelajaran berbasis masalah terhadap kemampuan komunikasi matematika siswa* [The effect of problem-based learning models on students' mathematical communication ability]. *Jurnal Matematics Paedagogic*, *VII*(1).

NCTM. (2000). Principles and standards for school mathematics. NCTM.

Ndia, L., Solihatin, E., & Syahrial, Z. (2020). The effect of learning models and multiple intelligences on mathematics achievement. *International Journal of Instruction*, *13*(2), 285–302. https://doi.org/10.29333/iji.2020.13220a

Nufus, H., & Mursalin, M. (2020). Improving students' problem solving ability and mathematical communication through the

application of problem based learning. *Electronic Journal of Education, Social Economics and Technology*, *1*(1), 43-48. https://doi.org/10.33122/ejeset.v1i1.8

Nurmala, I., Hidayat, W., & Hendriana, H. (2018). *Meningkatkan kemampuan komunikasi matematik siswa sekolah menengah pertama melalui pendekatan contextual teaching and learning* [Improving junior high school students' mathematical communication skills through a contextual teaching and learning approach]. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *1*(1), 21.

OECD. (2016). Programme for internasional student assessment *(PISA) Results From PISA 2015*. OECD Publishing.

OECD. (2019). Pisa 2018 results: what student know and can do. OECD Publishing.

Onwumere, O., & Reid, N. (2014). Field dependency and performance in mathematics. *European Journal of Educational Research*.

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education*, *10*(2), 522-534. http://doi.org/10.11591/ijere.v10i2.20640

Pangemanan, A. (2020). Application of contextual teaching and learning approach on statistics material against student results. *International Education Studies*, *13*(4), 1. https://doi.org/10.5539/ies.v13n4p1

Putri, D. P., Ferdianto, F., & Fauji, S. H. (2020). Designing a digital teaching module based on mathematical communication in relation and function. *Journal on Mathematics Education*, *11*(2), 223-236.

Qohar, A., & Sumarmo, U. (2013). Improving mathematical communication ability and self regulation learning of junior high students by using reciprocal teaching. *Indonesian Mathematical Society Journal on Mathematics Education*, *4*(1), 59-74. https://doi.org/10.22342/jme.4.1.562.59-74

Ramellan, P. (2012). *Kemampuan komunikasi matematis dan pembelajaran interaktif* [Mathematical communication skills and interactive learning]. Padang: FMIPA UNP.

Reigeluth, C. M., & Carr-Chellman, A. A. (2009). Instructional-design theories and models, volume III: Building a common knowledge base. Routledge.

Rohid, N., & Rusmawati, R. D. (2019). Students' mathematical communication skills (mcs) in solving mathematics problems: a case in indonesian context. *Anatolian Journal of Education*, *4*(2), 19-30. https://doi.org/10.29333/aje.2019.423a

Rusman. (2010). *Model-model pembelajaran (mengembangkan profesionalisme)*. Raja Grafindo Persada.

Rustam, A., & Ramlan, A. M. (2017). Analysis of mathematical communication skills of junior high school students of coastal kolaka. *J. Math. Educ.*, *2*(2), 45–50.

[a]ahenk, S. S. (2010). Characteristics of the headmasters, teachers and students in an effective school. *Procedia-Social and Behavioral Sciences*, *2*(2), 4298-4304. https://doi.org/10.1016/j.sbspro.2010.03.682

Sukma, O. N., Rukli, & Syamsuddin, A. (2022). *Penerapan model contextual teaching and learning terhadap kemampuan komunikasi matematis* [Application of contextual teaching and learning models to mathematical

communication skills]. *Jurnal Fakultas Keguruan Dan Ilmu Pendidikan Unipa Surabaya*, *18*(2), 55–69.

Tan, O.-S. (2003). *Problem-based learning innovation: using problem to power learning in 21st century*. Thompson Learning.

Tiningsih, S., Yuniarsa, & Octa, S. (2014). Writing skills enhancement using the contextual teaching and learning (ctl) approach in jayapura. *International Journal of Business, Economics and Law*, *5*(2), 19–21.

Tinungki, G. M. (2015). The role of cooperative learning type team assisted individualization to improve the students' mathematics communication ability in the subject of probability theory. *Proc.of the Fifth Conference for the Psychology of Mathematics Education*, *6*(32), 27–31.

Wawan, & Retnawati, H. (2022). Empirical study of factors affecting the students' mathematics learning achievement. *International Journal of Instruction*, *15*(2), 417–434. https://doi.org/10.29333/iji.2022.15223a