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Problem-based learning through lesson study learning community to enhance students' mathematical communication skills

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Abstract

The aim of this research is to describe students' mathematical communication skills by integrating information technology in a collaborative problem-based learning model designed by teachers and lecturers through a lesson study learning community. The research subjects were 36 students in grade tenth (X.4) at SMA Srijaya Negara Palembang in the 2023/2024 academic year. This research is a mix method with quantitative and qualitative techniques. This research has four stages, namely: plan, do, see, and retrospective analysis. The instruments of this research are test questions, observation sheets, and interview guidelines. Data analysis techniques use quantitative and qualitative. Test result data is scored based on a scoring rubric. Observation data is a percentage based on the appearance of indicators. Test and observation data are categorized into five categories, namely: very good, good, enough, less, and poor. Based on the results of data analysis, it was found that students were able to speak language and convey ideas for solutions well. However, there are students who have difficulty expressing concepts and reading mathematical notation both in writing and orally. This low ability is influenced by several factors such as low student activity during learning and discussions, low interest, lack of self-confidence, and from the cognitive aspect it is influenced by low levels of accuracy and habits in solving problems. So, it can be concluded that students' mathematical communication skills after learning using a problem-based learning model and integrating information technology through lesson study learning communities are categorized as enough.

Keywords*: Problem-based, Lesson Study, Learning Community, Mathematical Communication.*

Abstrak

Tujuan penelitian ini adalah untuk mendeskripsikan kemampuan komunikasi matematis siswa dengan mengintegrasikan teknologi informasi dalam model pembelajaran berbasis masalah secara kolaboratif didesain oleh guru dan dosen melalui *lesson study learning community*. Penelitian dilaksanakan di kelas X.4 SMA Srijaya Negara tahun ajaran 2023/2024 yang berjumlah 36 orang menggunakan penelitian kombinasi *(mixed method)*. Penelitian kombinasi terdapat dua metode yaitu kuantitatif dan kualitatif. Penelitian ini memiliki empat tahapan, yaitu: *plan, do, see,* dan *retrospective analysis*. Instrumen penelitian ini adalah soal tes, lembar observasi, dan pedoman wawancara. Teknik analisis data menggunakan kuantitatif dan kualitatif. Data hasil tes diskor berdasarkan rubrik penskoran. Data hasil observasi dipersentase berdasarkan kemunculan indikator. Data tes dan observasi dikategorikan menjadi lima kategori yaitu: sangat baik, baik, cukup, kurang, dan sangat kurang. Berdasarkan hasil analisis data diperoleh bahwa siswa mampu berbahasa dan menyampaikan ide untuk penyelesaian dengan baik. Namun, ada siswa kesulitan mengemukakan konsep dan membaca notasi matematika baik secara tertulis maupun lisan. Rendahnya kemampuan ini dipengaruhi oleh beberapa faktor seperti rendahnya keaktifan siswa saat pembelajaran dan diskusi, rendahnya minat, kurangnya

rasa percaya diri, serta dari aspek kognitif dipengaruhui oleh rendahnya tingkat ketelitian dan kebiasaan dalam menyelesaikan masalah. Sehingga dapat disimpulkan bahwa kemampuan komunikasi matematis siswa setelah dilakukan pembelajaran menggunakan model pembelajaran berbasis masalah dan mengintegrasikan teknologi informasi melalui *lesson study learning community* terkategori cukup baik.

Kata kunci: Pemecahan masalah, Pembelajaran berbasis masalah, Komunitas belajar, Komunikasi matematis

INTRODUCTION

In this era, many things have changed in terms of various aspects of human life, including education. Students are required to have the ability to think critically, solve problems, be able to communicate, absorb and filter information well, as well as the ability to work together in solving existing problems (Inganah et al., 2023). Therefore, the current learning paradigm has also changed (Almeida & Simoes, 2019). Learning is adapted to the times and developments in science. Good learning is not only supported by a conducive learning atmosphere, but is also able to guide and familiarize students to work together well and be able to build good communication relationships with teachers and other students (Richardson & Mishra, 2018).

Communication skills have a very important role in the process of learning activities in the classroom because they are not only the main provision for students to develop and produce more knowledge than just completing work independently but can also build knowledge through exchanging ideas and unifying opinions in order to obtain the best solution to the problemis being faced (Engelbrecht et al., 2020). Communication skills are needed by students to convey thoughts and expand understanding (Rohid et al., 2019). Through communication, students will be able to understand a concept by writing or explaining it, including providing reasons for their thought process. Through writing or verbally, students will be able to build an understanding of the ideas they have learned and communicate these ideas to other students so that other students can also formulate their own ideas systematically (Ali, 2019).

Mathematical communication skills consist of oral and written communication (Amany et al., 2023). Oral communication such as discussion and explaining (Triana et al., 2019). Written communication such as expressing mathematical ideas through pictures/graphs, tables, formal or informal mathematical expressions, or using the students' own language or sentences (Hafni et al., 2021). Communication skills include

the ability to express mathematical ideas verbally, in writing, also demonstrate and illustrate them visually (Triana et al., 2019).

Before this research was carried out, the teacher and researcher conducted a joint reflection regarding the learning that the teacher had carried out so far in tenth grade. From the results of the reflection, information was obtained that so far the mathematics teachers at SMA Srijaya Negara have tried to carry out learning based on problem-based learning. Students are sometimes given assignments or problems to work on together or in the form of group discussions. During the learning process, it was seen that the teacher only occasionally asked students questions and asked students to form study groups. Apart from that, it was found that students' mathematical communication skills were relatively low, both verbally and in writing. Students still experience problems in making mathematical representations in written form, either in visual form or mathematical notation. Apart from that, some students are less capable and less clear in presenting ideas from discussions during presentations in front of the class.

Before the research was carried out, the researcher also made observations in the tenth grade to get a direct picture of how teachers carry out learning and what students' activities and motivation are in class. Based on the results of class observations, it was found thatstudent motivation tends to be low. There are some students who tend to feel bored during learning and do not want to be involved in discussions. It seems that only students with high abilities are active in class. However, discussions are rarely held because it requires quite a long portion of time for students to observe problems, dig up information, discuss and present relatively little.

Learning materials are in the form of formal concepts so that when the teacher explains, sometimes students find it difficult to imagine the situation of the problem that students are studying or solving. Apart from that, based on the results of observations in class The learning methods and strategies used by teachers are sometimes not carried out optimally. Apart from that, mathematics teachers revealed that they rarely use learning media, both conventional media and ICT-based media.

From previous research, it was found that there are several strategies that can be used to develop students' mathematical communication skills and motivation. According to Hidayat & Aripin, (2023) that E-LKPD with a scientific approach influences students' mathematical communication abilities. Using worksheets based on problem-learning also can enhance mathematical communication (Riyati & Suparman, 2019). Perwitasari & Surya (2017) also added thatlearning material using problem-based learning can improve mathematical communication ability of secondary school students. Beside that there is

influence of cooperative learning with interactive media assistance to students' mathematical communication ability (Yarmasi et al., 2020). Beside that using information technology in learningas well as an online learning media design can improving students' mathematical communication (Fauzia et al., 2021).

Based on the problems and previous research that have been described before an innovative and creative learning innovation like problem-based learning models in small groups using student worksheets and information technology in learning is needed that can be used to facilitate students in developing their mathematical communication skills. One strategy is to integrate information technology in a problem-based learning model that is designed collaboratively between teachers and lecturers through lesson study learning communities to enhance students' mathematical communication skills. So, the aim of this research is to describe students' mathematical communication skills by integrating information technology in a collaborative problem-based learning model designed by teachers and lecturers through a lesson study learning community.

METHOD

The research was carried out in class X. 4 of SMA Srijaya Negara for the 2023/2024 academic year, totaling 36 people. The study used mixed methods, which Creswell (2014) defines as combining quantitative and qualitative data in a single study. It employed an explanatory sequentialdesign, which entails collecting quantitative data first, then collecting qualitative data tointerpret the results of the quantitative study. The study collected quantitative datathrough the test and observation. Then, qualitative interviews aimed to determine the reasons for the quantitative results. Figure 1 shows the design of the study.

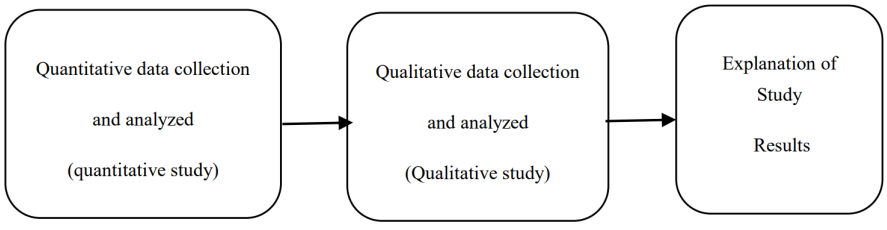

Figure 1.Scheme of the mixed methods study procedures

The use of these two methods together is carried out with the aim of making the data obtained more comprehensive, valid, reliable and objective (Dawadi et al., 2021). To achieve the stated research objectives, researchers used lesson study. This research

consists of four stages, namely: plan, do, see, and retrospective analysis which is depicted as follows.

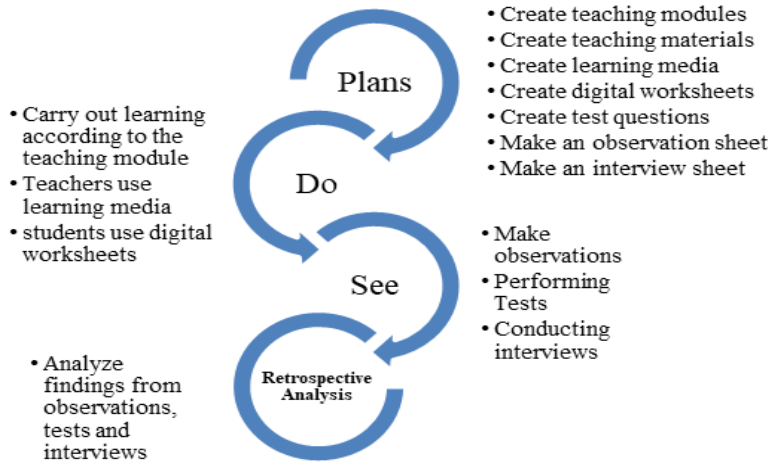

Figure 2. Research stages

The research instruments used were test questions, observation, and interview. The test used is in the form of multiple-choice questions arranged from easy to difficult, consisting of 8 questions. Observation sheets are used to observe students' collaboration abilities during learning. The interviews used were semi-structured in accordance with interview guidelines. Interviews were conducted with the aim of finding out broader and more open information about students' understanding, mathematical communication and the obstacles students experienced during learning.

The data analysis techniques used in this research are quantitative and qualitative. The data analysis stage was carried out quantitatively and continued with qualitative data analysis carried out for test and observation data. Test result data is scored according to the scoring rubric. Scoring guidelines refer to mathematical communication skills which include: (1) using terms, mathematical notation and structures to present ideas, describe relationships and model situations, (2) connect real objects, pictures and diagrams into mathematical ideas; (3) explain mathematical ideas, situations, and relations orally or in writing with real objects, pictures, graphs, and algebra; (4) express everyday events in language and mathematical symbols; (5) listening, discussing, and writing about mathematics; (6) read with comprehension from a written mathematics presentation; (7) formulate opinions and formulate definitions; (8) explain and create mathematical questions that have been studied. Observation data is a percentage based on the appearance of indicators. Both test and observation data are categorized as follows.

Table 1. Categories of mathematical communication skills

Percentage	Category
81 ≤ score ≤ 100	Very good
61 ≤ score ≤ 80	Good
41 ≤ score ≤ 60	Enough
21 ≤ score ≤ 40	Less
0 ≤ score ≤ 20	Poor

RESULT AND DISCUSSION

Plan

On July 25th, 2023, the model teacher together with lecturers and other partner teachers designed and developed innovative learning tools in accordance with the demands of the Independent Curriculum and in line with the challenges to be resolved. The material chosen is Number Patterns and Object Configuration. The learning tools developed consist of teaching modules, teaching materials, student worksheets, media, and evaluation. The teaching module not only contains identity, learning outcomes, learning objectives, flow of learning objectives, trigger questions, but also contains learning and assessment methods, both initial and final assessments. In the teaching module, learning uses a problem-based learning model which consists of 1) Orienting students to problems; 2) Organizing students to learn; 3) Guiding individual and group investigations; 4) develop and present work results; and 5) Analyze and evaluate the problem-solving process.

Apart from that, the teaching module also contains attachments in the form of teaching materials, learning media, student worksheets and assessment instruments. The teaching material attached is in the form of a handout which is a summary of material about number patterns and object configurations and contains factual knowledge, conceptual knowledge, and procedural knowledge. The learning media in this first cycle was created using Canva. This media is a means for teachers to convey learning objectives and basic concepts of the material to be studied. Student worksheets are made digital and use the Wizer.Me application. On the student activity sheet there is a video about number patterns and object configurations. Apart from that, the activities on the worksheet are varied, consisting of description questions, filling in columns and drawing patterns. The assessment instrument consists of assessing cognitive, affective, and psychomotor aspects. The assessment for the cognitive aspect is in the form of a description test consisting of 3 questions.

During the planning, discussion did not take into account the initial analysis regarding student characteristics (González et al., 2020) because the teacher did not yet have a description of the data regarding student characteristics. The selection of learning topics is not based on an analysis of student needs but is adjusted to the learning implementation schedule that suits the school. The lesson planning that was delivered had been made by the model teacher independently (Çolak, 2017), then presented during the planning stage and was not actually prepared together with team members. This is because not all of the lesson study team members are mathematics teachers, so they do not really understand the mathematics content. Apart from that, the limited time to gather together to discuss lesson plans due to the teacher's teaching load of at least 24 hours per week means that the opportunity to gather makes planning difficult. Based on observations, lesson study planning activities are carried out in very limited free time (Cajkler et al., 2014), for example during breaks which only last around 30 to 60 minutes, making it less possible to develop lesson plans and other tools from scratch together.

Do

On August 9th, 2023, the first cycle of open classes was held for mathematics subjects. After the activity opened the class, the teacher presented trigger questions and apperception using power point. To arouse student motivation, the teacher presents a problem in the form of an object configuration in the form of a triangular arrangement and continues by explaining a little about the concept of patterns and number sequences.

Next, the teacher provides a series of contextual problems as the starting point of the problem-based learning model according to the topic of number patterns and sequences. The teacher gives each group time to observe the learning video on the digital worksheet. Students are guided to determine the pattern in an arrangement of objects using a digital worksheet correctly. After students can find the pattern of the arrangement of these objects, students are also guided to generalize this pattern so that the nth term of the number sequence can be formulated. During learning the teacher only acts as a facilitator. During the discussion, the teacher gives students the opportunity to work in groups to find solutions to problems and observes all student activities in the group. Learning that uses the PBL model allows students to analyze problem collaboratively and learn independently (Yusof et al., 2012). The teacher goes around to provide guidance to students or groups who need scaffolding to think creatively in solving problems. At the end of the group discussion, the teacher also directs students to share and discuss all the findings and initial solutions they have produced.

PBL is a curriculum development and instructional system that simultaneously develops both problem-solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured problem that mirrors real-world problems (Chan & Ho, 2014). Every lesson with PBL always begins with a problem. The stages of the problem-solving process are used as a framework or guide in the PBL learning process. In PBL students solve problems by conducting experiments and investigations through reading. Reichman, (2015) explained that the learning process in PBL also leads to learning to know (learning about facts, skills, concepts, and principles), learning to do (doing mathematics), learning to be (enjoy learning with mathematics), and learning to live together (cooperative learning in mathematics)

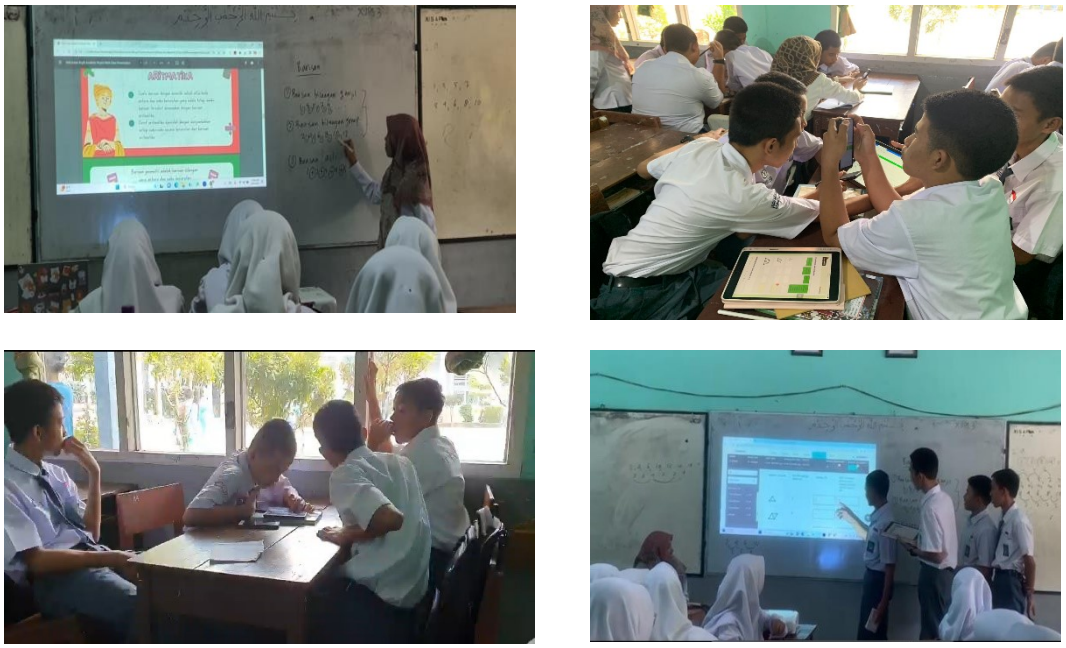

Figure 3. Learning process

In the next stage, the teacher gives one group the opportunity to present their solution in front of the class orally and invites students from other groups to provide questions and comments regarding the solution presented. As reinforcement, the teacher provides a more in-depth explanation of concepts and theories related to the topic, especially those containing facts, definitions, formulas and rules relevant to number patterns via power point.Through problems, students are trained to think divergently/ creatively to generate as many ideas as possible regarding a problem and communicate them in various forms (Bicer et al., 2019). Students are trained to think convergently by

using logical-critical reasoning in considering or formulating the most appropriate answer. So that students' problem-solving abilities and mathematical communication skills develop. Apart from that, the problems contained in learning activities also develop, directing students to new mathematical knowledge, solving problems both in mathematics and other contexts by applying various suitable strategies and being able to reflect on the processes that have been carried out in solving problems.

In the closing activity, the teacher directs students to draw conclusions regarding the learning patterns and number sequences they have studied. The teacher also gives two test questions in the form of a description as a form of summative evaluation. This summative test is used not only to determine student understanding but also to determine mathematical communication skills from a written aspect. At the end of the lesson, the teacher gives additional problems as assignments at home and informs about the material that will be studied at the next meeting, and closes the lesson by praying together.

Overall, learning went smoothly, because the teacher had implemented problem-based learning (Ngadiso et al., 2021).At each open class activity, the observers present ranged from eight to nine people on average. The number of observers present is generally one observer observing one group, so that each student can be observed well. Observers usually make observations from the side or behind the students, but there are also those who are in the middle of the students. Only at the beginning of the learning activity did the students seem stiff with the presence of the observer (Budiman et al., 2017). The presence of observers is quite effective in helping model teachers observe their students in learning. Apart from that, the situation in the classroom also feels calmer. However, it was still found that there were several observers who talked to fellow observers even though the duration was not long, still used cellphones (not for the purpose of their duties) and there were also those who tried to straighten out students if students made mistakes in solving problems.

See

The next stage is reflective analysis for mathematics subjects. This reflective analysis activity begins with the model teacher reflecting on the learning he has carried out. From the results of the reflection, it was found that in general the learning activities carried out by the model teacher were in accordance with the learning planning. However, at the end of the activity, the model teacher forgot to invite students to draw conclusions and did not have time to give them additional assignments to do at home. Apart from that, the model teacher also observed that several students experienced problems with their cellphones, resulting in them being quite slow in working on the

questions on the digital worksheet. Model teachers also feel that there are still too many problems displayed on digital worksheets. There were several groups who only solved some of the problems on the digital worksheet, but in general it can be concluded that the learning carried out was quite good.

Based on the results of observations during learning, in general the students in each group were also active. Students in groups 4, 5, 6, 7 and 8 have all contributed actively. The distribution of tasks for group discussions also went well. The focus of observation is aimed at looking at student activities in groups which consist of students' skills in explaining and conveying material or concepts during discussions, students' skills in providing input or ideas during discussions, language clarity and the ability to read mathematical notation contained in the problem. In PBL, students are encouraged to communicate ideas, reflect on their completion through discussion. This activity helps students build understanding. When students are challenged to think and make reasons about mathematics and communicate the results of their thinking to others, either verbally or in writing learn to explain and self-confidence. PBL is a learning model that centers students from being passive listeners of information to being active, developing problems and problem-solving skills. In the PBL model students learn based on problems. Students discover the concepts they learn through solving problems they find, so that students are trained to find solution steps independently. This is in accordance with the statement (Handika & Wangid, 2013) that problem-based learning is a learning model that places more emphasis on solving problems or problems as a starting point or basis in the learning process. Students' verbal mathematical communication abilities are illustrated in Figure 4.

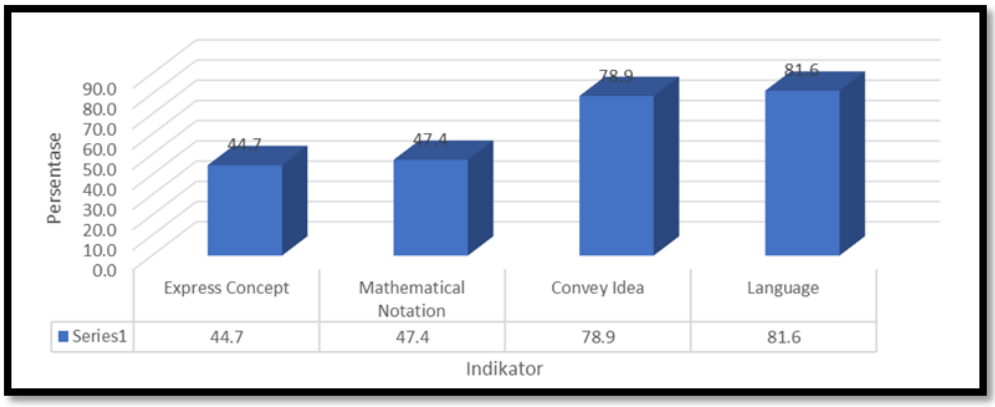

Figure 4. Oral mathematical communication ability diagram

From the observation results, it was found that 78.9% of students were able to convey ideas for solutions and 81.6% of students were able to speak the language well. However, only 44.7% of students were able to express concepts from the material being studied and only 47.4% of students were able to read mathematical notation well during discussions. Low oral mathematical communication skills are also influenced by several things. If we look at students' involvement in discussions, it is found that there are still students who are less active and only copy answers from their friends (Sari et al., 2019). There are also students who tend not to speak up much, but after being interviewed these students feel less confident in conveying their ideas to other students (Purba & Surya, 2019. Apart from that, there are also students who do not want to be involved at all during learning. From the results of the interview, information was also obtained that the student did not like mathematics subjects (Hidayati et al., 2020).

From the test results, it was also concluded that students' written mathematical communication skills were still enough. From the answers to the written mathematical communication skills test, it was found that 28.9% of students were categorized as good, 26.3% of students were categorized as enough and 34.2% of students were categorized as less. From the observation results, it is known that students who do not meet the indicators of written and verbal mathematical communication skills include not being able to represent in the form of images or symbols, being incomplete in writing/ explaining what is asked, and sometimes being afraid of making mistakes in conveying or writing down solutions to problems. This is in line with the opinion of Wardhana & Lutfianto, (2018) who stated that students who lack self-confidence, lack confidence in their abilities and lack the courage to express opinions in solving problems, including understanding problems, thus affecting their mathematical communication skills. Students' mathematical communication abilities are generally depicted in **Figure 5**.

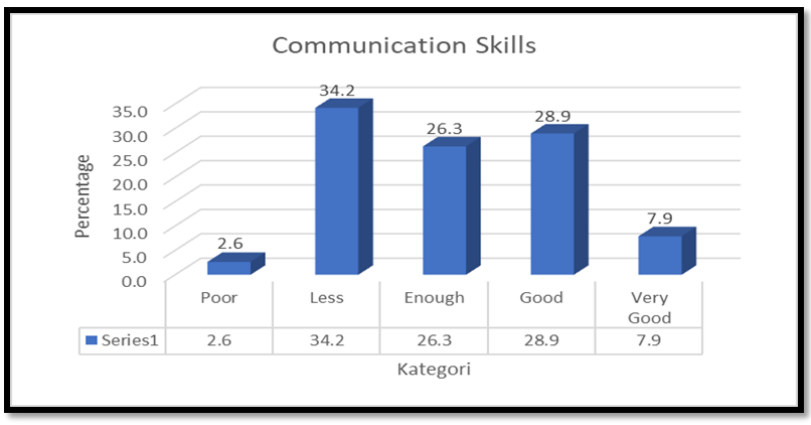

Figure 5. Diagram of general mathematical communication skills

If we look at the problem solving, especially for question number 1, many students communicate their solutions using visual images and non-formal mathematical expressions. If the questions presented are structured and there are examples of patterns, then students will also solve according to the examples (Renkl & Atkinson, 2003). If the questions presented are structured and require students to describe first, especially if there is an example of the pattern, then students can also describe the next pattern. From the test results, not all students who were able to describe patterns were also able to find regularities in mathematical expressions expressed in general form for the nth term. There are also students who are not careful in observing patterns in object configurations which also results in errors in writing mathematical expressions. From the results of the analysis of student answers, it was also found that students who were incomplete and lacking in detail in identifying problems and planning them tended to be unable to communicate and interpret what concepts would be used to solve mathematical problems, and this resulted in them not being able to solve problems well (Alhaddad et al., 2015).

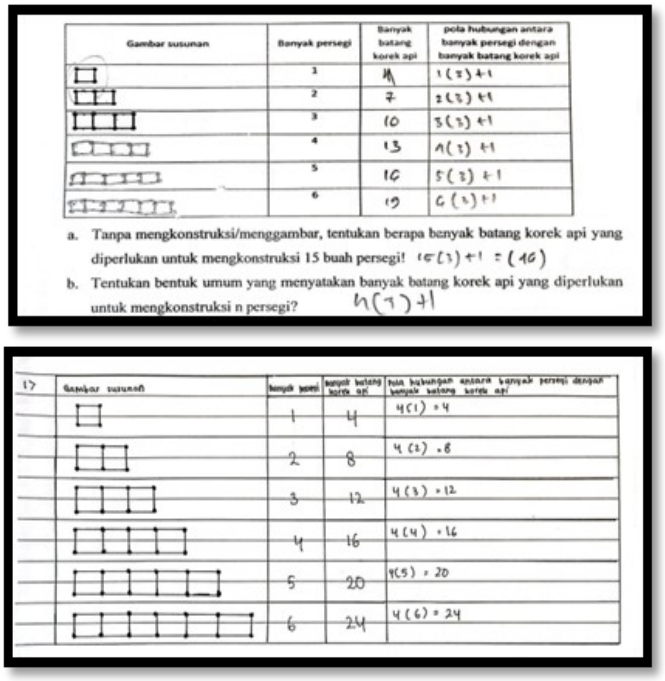

Figure 6. Answer number 1

Firdaus, (2016) states that mathematical communication is important for students to convey their ideas, perceptions and mathematical solutions to others. In **Figure 7** as answer for question number 2, students communicate the solution in different forms. There are those who communicate with pictures, formal and informal mathematical

expressions, and there are also those who use words. This arises for problems that are created in the form of story problems without being required to describe them first. Students communicate mathematics based on their knowledge and understanding (Tinungki, 2015).

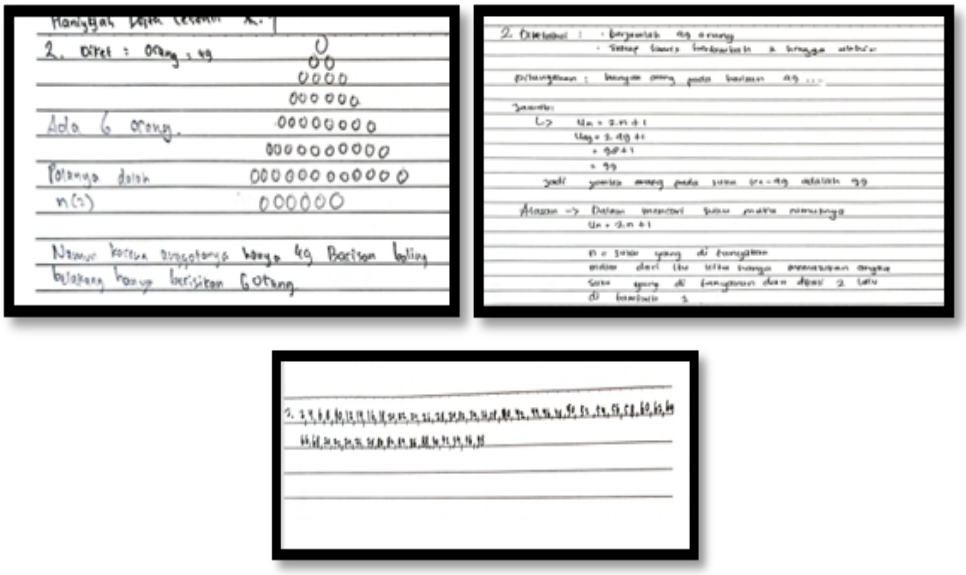

Figure 7. Answer number 2

In question number 3, most students communicated the solution to the problem given in the form of a formal mathematical expression. This arises for problems that are created in the form of story questions without being required to describe them first as shown in **Figure 8**.

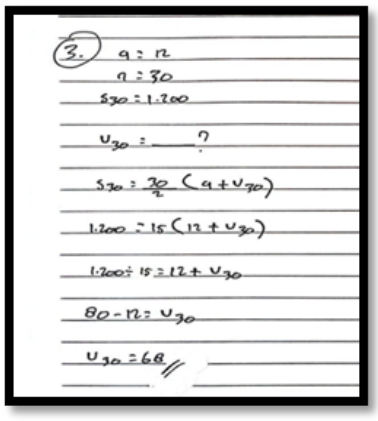

Figure 8. Answer number 3

If we look at written communication indicators, it is found that the majority of students still use formal mathematical expressions for mathematics words problem

(Kieran, 2018). From the test results, it was found that 44.7% of students communicated solutions visually, 55.3% of students communicated using formal expressions, 42.1% used non-formal expressions, and 39.5% used words or sentences. Test questions that are deliberately designed for communication skills make it easier for students to convey information to others through spoken language or written symbols, including charts, maps or other demonstration tools.Students' mathematical communication skills in writing are illustrated in **Figure 9.**

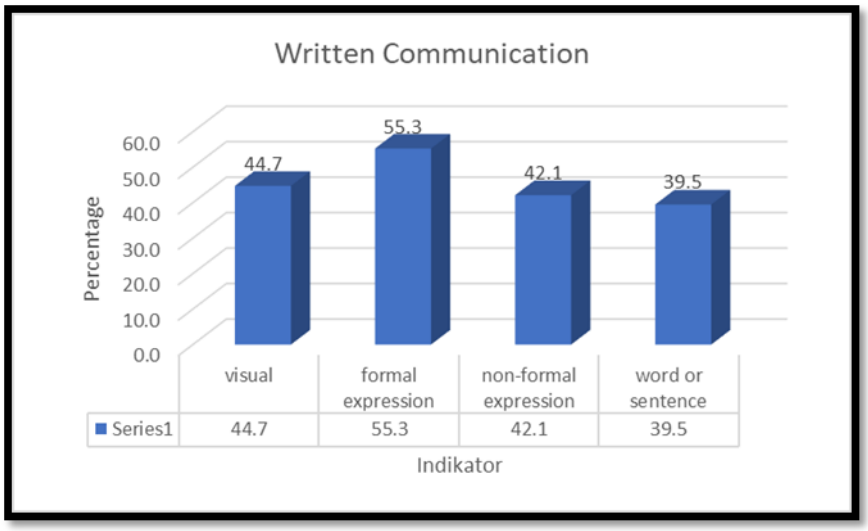

Figure 9. Indicators of written mathematical communication ability

CONCLUSION

Based on the results of data analysis, it was found that students were able to speak language and convey ideas for solutions well. However, there are students who have difficulty expressing concepts and reading mathematical notation both in writing and orally. This low ability is influenced by several factors such as low student activity during learning and discussions, low interest, lack of self-confidence, and from the cognitive aspect it is influenced by low levels of accuracy and habits in solving problems. So, it can be concluded that students' mathematical communication skills after learning using a problem-based learning model and integrating information technology through lesson study learning communities are categorized as enough.

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