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Mathematical Communication Ability Analysis in E-Learning Environment Assessed from Student Self-Regulated Learning

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Abstract:

The research aims to find: the factors causing the low mathematical communication ability of students, ways to increase mathematical communication in terms of independent learning and recommendations for student success. As a subject for elementary level students of the undergraduate mathematics education program, Pancasakti University,Tegal-Indonesia. The data were collected by means of tests, observations, interviews and documentation, then triangulation was carried out to check the truth and analyzed descriptively. The results showed students' mathematical communication ability to describe mathematical symbols, ideas, structures and sentences to complete, but they got deadlock in communicating between components into mathematical sentences. Searching for student work portfolios is not procedural. Recommendations, to improve mathematical communication ability, a module-assisted e-learning is carried out which contains various basic materials and enrichment materials. When online students are given assignments to study and work on questions from previously given modules to strengthen their independence learning. This is to lure students to improve their mathematical communication ability. When face-to-face is used as a forum for discussion, highly capable students help become tutors. Here the lecturer facilitates students to interact by giving questions that show mathematical communication and giving examples of work with good mathematical communication.

Keywords: Mathematical Communication Ability, E-learning, Independence Learning

Introduction

Mathematical communication ability is the ability of students to convey mathematical ideas both orally and in writing. According to (P**rayitno et al., 2013, p. 384)**, mathematical communication is a student way of expressing and interpreting mathematical ideas orally or in writing, either in the form of

pictures, tables, diagrams, formulas, or demonstrations. Meanwhile, mathematical communication according to Romberg and Chair is: (1)the ability to connect real objects, pictures and diagrams into mathematical ideas, (2) explaining mathematical ideas, situations and relations orally or in writing with real objects, pictures, graphics and algebra, (3) expressing daily events in language or mathematical symbols, (4) listening, discussing and writing about mathematics, (5) reading with the understanding of a written mathematic presentation, making conjectures, compiling arguments, formulating definitions and generalizations, (6) explaining and making questions about math you've learned **(Qohar & Sumarmo, 2013, p.46).**

The process is an exchange of ideas which includes listening and reading (understanding), speaking and writing (expressions). What is unique in mathematics expressions can also include representations of mathematic ideas. For students, the learning outcomes of mathematics are an activity in using mathematical communication ability to solve the problems they face to achieve the desired goals. Therefore, students' mathematical communication ability needs to be developed. To improve mathematical communication ability, To develop mathematical communication according to Pugalee (2003) states that students are motivated to provide relevant reasons for their answers or statements and comment on other opinions so that students are able to understand the mathematical concepts that are learned meaningfully (Qohar & Sumarmo, **2013**, p. 64). To develop mathematical communication according to (**Clark** et al., 2005) "four strategies are needed, namely specifically focusing on four strategies that seem to be the basis for creating a community of mathematical discourse: (1) rich tasks, (2) safe environments, (3)) students' explanation and justification, and (4) idea processing" (p.1).

The stages of students' mathematical communication begin with listening, reading, discussion and brainstorming problems related to mathematics can be expressed orally, as a form of oral mathematical communication or expressed in writing as a form of written mathematical communication. Oral communication is carried out when reading, listening to listening, discussing, explaining and sharing. For written communication, it is used to write vocabulary, notation, and mathematical structures in the form of tuning, connection, and problem solving (**Ansari, 2018, pp. 16-17**)

The role of mathematics communication according to (Clark et al., 2005) as: (1) a tool to exploit mathematical ideas and help students 'ability to see the various relationships of mathematical material, (2) a tool to measure the growth of understanding and reflect on students' mathematical understanding, (3) tools for organizing and consolidating students' mathematical thinking, and (4) tools for constructing mathematical knowledge, developing problem solving, increasing reasoning, fostering self-confidence, and increasing social skills.

Besides (**Barrody, 1993**) provides reasons, namely (1) mathematics is the language (mathematics as language); mathematics is not just a tool to aid thinking, a tool to find patterns, a very valuable tool for communicating various ideas clearly, precisely and smoothly (an invaluable tool for communicating a variety of ideas clearly, precisely and succinctly). (2) Mathematics as a social activity, in teaching mathematics, such as interaction between students, teacher-student communication is an important part of nurturing children's mathematical potential. Through communication mathematical ideas can be reflected, corrected, discussed and developed (**Hodiyanto**, 2017).

The communication process helps to build understanding and perpetuate ideas and make them public.

When a student is given a math problem and is required to convey ideas orally or in writing, they are actually carrying out learning activities to explain and convince the problem. This activity can foster independence in learning mathematics.

From the opinion of experts from various sources, it can be concluded that communication ability is an important part of mathematics and mathematics learning that needs to be developed. The problem of students of mathematics education study program in developing the mindset of mathematics communication ability still faces many obstacles. In general, when students are given questions in the form of story questions, the answers they give are the results of trial and error, not resolved systematically according to the correct conceptual and procedure. Therefore it makes students less sure of the results they give.

Judging from the input of students from the Pancasakti Tegal University Mathematics Education study program who came from various high schools. They come from Senior High Schools both from the Natural Science program and from the Social Science program as well as from Vocational High Schools. This is what makes it difficult for lecturers to get their students to achieve their mathematical communication skills. It is important to explore students' problems by looking at the dominant indicators that determine their improvement.

To help students learn independently in order to support their ability to communicate in mathematics, there are already e-learning facilities. It seems that with the help of these tools, the results also show little improvement in his mathematical communication ability. This is where the researcher tries to explore the problem to find recommendations for alternative solutions to the problems mentioned above. The purpose of this study is to obtain in-depth information about the root of the problem and the factors that influence students not to their mathematical communication ability. The benefit of this research is that it obtains recommendations on how to bring new students to accelerate their mathematical communication ability.

Mathematical communication needs to get attention in learning mathematics, because with communication, students can organize mathematical thinking (**NCTM** 2000, n.d.). According to **NCTM (1989)**, the role of communication for students is to: (1) Organize and combine their mathematical thinking through communication; (2) Communicate their mathematical thinking coherently and clearly to peers, teachers, and others; (3) Analyze and evaluate the mathematical thinking and strategies of others; (4) Use mathematical language to express mathematical ideas appropriately.

There are several factors that can influence student learning success, both internal and external factors. Factors that affect students 'low problem-solving abilities include students' mathematical reasoning and communication. Mathematical reasoning and communication are inseparable, namely mathematics material is understood through reasoning, and reasoning is understood and then trained through learning mathematics material until it is able to communicate (**Purba** et al., 2017).

To improve the qualifications for student learning space, a learning process is needed that is adjusted to the development of science and technology. Current learning that utilizes information technology uses e-learning. E-learning is learning that utilizes information and ommunication technology, especially in electronic form. According to **Michael (2013**) -learning is an education system or concept

that utilizes information technology in the teaching and learning process. **Rusman (2012**) e-learning is all learning activities that use the help of electronic technology. In addition, **Chandrawati (2010)** argues that e-learning is a distance learning process by combining principles in the learning process with technology. In addition, **Ardiansyah (2013)** explains that e-learning is a learning system that is used as a teaching and learning process that is carried out without having to come face to face with directly between educators and students. From the opinion of some experts, it can be concluded that e-learning is a learning process that uses information technology, carried out by distance learning without having to come face to face directly between educators and students.

In the implementation of learning with e-learning, not only the devices used are not only the internet, but all electronic devices such as films, videos, tapes, OHPs, slides, LCDs, projectors, and others. E-learning learning is carried out online using the Learning Management System application that is already available using a computer or mobile phone connected to the internet. So that learning is not limited to distance, space and time, it can be done anywhere. So e-learning can be done with all electronic media that support the learning process. E-learning can be applied to conventional and distance education.

The framework of this research is to deepen like a basic level student. In essence, elementary level students are still influenced by the mindset at school level. More complex problems are experienced because the background of student input is very heterogeneous. The steps in which people get used to training their abilities in mathematical communication are the center of research attention. Through deepening the students' problems when solving problems related to mathematics communication, the root of the problem will be found. Besides that, the implementation of e-learning will give students the opportunity to improve themselves in order to practice their ability to develop mathematical communication. The factors that affect the difficulty of students in performing mathematical communication ability are used as a reference for deepening. By triangulating, we will find the problem we are aiming for.

Research Methods

This type of research is qualitative research. The scope of this research is to deepen the problem of the low level of mathematical communication skills of elementary level students of the mathematics education study program of Pancasakti University, Tegal. The subjects of this study took representative subjects of students from high schools majoring in natural sciences, high schools majoring in social science, and vocational high schools from various majors. The focus of this research is mathematical communication ability resulting from independent learning both face-to-face and online (e-learning). Data collection of students' mathematical communication ability was carried out by means of a test for space geometry material. Indicators for analyzing mathematical communication ability: (1) Describing mathematical problem situations and mathematical ideas in written or oral form; (2) Describing the problem situation and state the design of the problem solution using algebraic formulas or pictures; (3) Using terms, mathematical symbols and structures to present ideas, describe mathematical relationships and models; (4) Using comprehensive representations to express mathematical concepts and plan their solutions; (5) explaining ideas, situations, and mathematical relationships in writing or orally or with real objects, images and algebraic forms.

The results of the data analysis of mathematical communication ability are from the spatial geometry

material test, then deepening by means of triangulation, namely observation, in-depth interviews, documentation to cross check the data, then analyzed descriptively (**Sukestiyarno, 2020**).

Research Results

The results of the observation that students from non-SMA-IPA, namely from SMA-IPS, MA and SMK have a lot of difficulty solving story questions, especially in providing ideas or objectives for the purpose of the questions, they seem more anxious and stressful in working on the questions when compared to students from SMA-IPA, students from SMA-IPA can show the work steps of their mathematical communication ability even though some are still incomplete. The implementation of independent learning (e-learning) can be seen that the responsibility of students from IPA SMA is good, while those from non-SMA IPA in face-to-face learning are more serious, but for the tasks given online there are still many that are lacking, some are incomplete, there are assignments but borrowed from friends. Intensive communication outside of their learning (online learning) is more serious, there is good communication between them.

The results of in-depth interviews with several subjects responded to the results of the work to solve geometric problems of space, the obstacles faced by students, when studying mathematics at the high school level it is not usual to solve problems in the form of descriptions, most of the questions are in objective form. In answering the question a lot of trial and error, because you just need to choose the answer that is available. When given problems in the form of descriptions or daily problems, they experience difficulties. Solving questions in the form of description is required to be able to use good mathematical communication to be able to solve problems.

Obstacles in the implementation of e-learning for students, among others, the availability of the internet network in the area where they live is unstable, the communication tools and media used in learning are inadequate. The results of interviews with several students obtained information on how to learn mathematics, especially Spatial Geometry, which still uses the methods used by teachers at school. In teaching the teachers do not provide the correct basic concepts, besides that for students from non-SMA-IPA, the discussion of Spatial Geometry material is not as deep as students from SMA-IPA.

In a situation like the conditions above, of course it is very difficult for lecturers to give different treatment in order to help them. In fact, self-learning based on e-learning provides many opportunities for students to study more seriously, have discussions outside the classroom, communicate with each other, look for other references that support their assignments. If this opportunity can be used properly, it will help those who are weak a lot. It's just that it takes a struggle for those who are weak how to show responsibility and for those who have high abilities there is a willingness to do the service of fellow friends. Here the role of the lecturer can also be used as a place to ask questions through social networks.

In independent learning based, on e-learning internet facilities and media used such as computers, laptops and mobile phones must be ready to use, meaning that the media is connected to the internet. If the media used is not perfect, it will cause student anxiety in communicating with lecturers for discussion, downloading material, sending assignments and discussions as well as discussions between students.

The stages of Independent learning based on e-learning are carried out by learning independently, both alone and in groups as well as online group discussion activities. In the discussion, a student group with heterogeneous members was formed so that students from the SMA-IPA group could help students from MA, SMA-IPS and SMK in solving mathematic problems.The results of the analysis of student work portfolios and in-depth interviews related to the portfolio show the following:

1. Students experience in describing problem situations and state the design of the problem-solution using pictures. This means that students could not use the figure of space in painting a straight line if two points are found on one plane and did not know the position of the lines in the space. Thus, students could not paint a line that passes through two points that are located on two different planes.

Through interviews, it was found that the reason why students were unable to paint a line correctly is that two points are located on different planes. The information obtained was that students had difficulty imagining the position of the lines in space.

Example of solution: Figure 1 the student's solution paints a point through the line on a plane. Students experience in describing problem situations and state the design of the problem-solution using pictures. This means that students could not use the figure of space in painting a straight line if two points are found on one plane and did not know the position of the lines in the space. Thus, students could not paint a line that passes through two points that are located on two different planes.

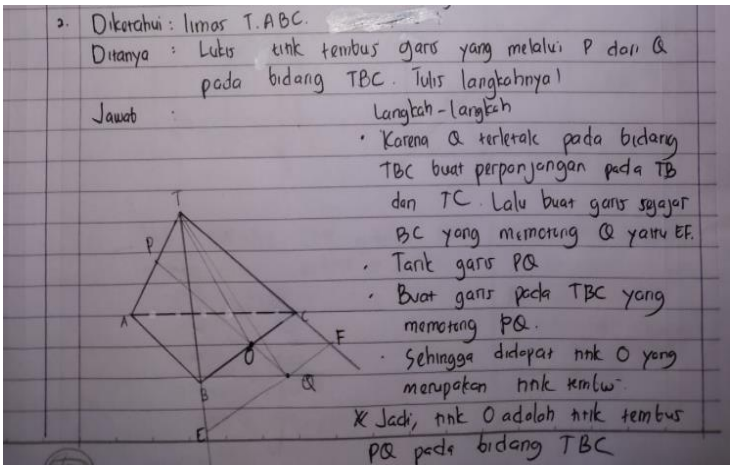


Figure 1. Line through the plane

During the meeting with students, the lecturer discussed the mistakes made in solving the problem of line breakpoints on the plane in the shape of a space, including the position of points, lines and planes in the shape of the space.

The results of the discussion are presented as in Figure 2.

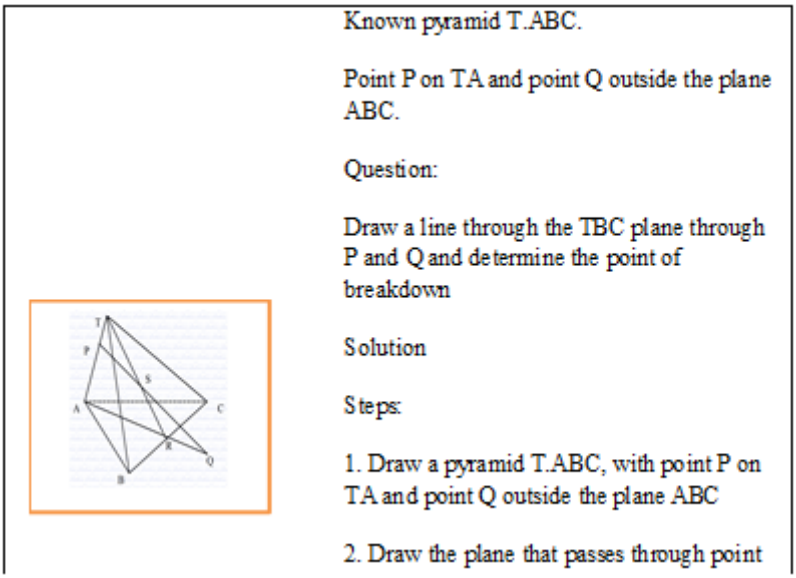


Figure 2. Point through lines and planes in space

2. Students had difficulties in using a comprehensive representation to express concepts and plan solutions. In this problem, to solve the intersection of two fields, students must know the basic concept of the intersection of two fields and be able to make sketches. In sketching two intersecting areas, students generally did not experience difficulties, but in making the intersection lines, students experienced difficulties. Through interviews, it was found that students did not know how to find out the position of the intersection of the two intersecting fields.

Example of solution: Figure 3, the student's solution determines the intersection of the two fields in space.

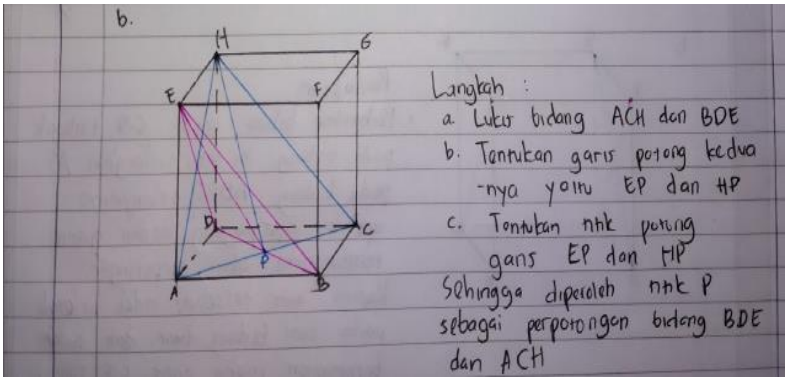


Figure 3. The intersection of the two fields in space.

From this paper, information was obtained that students were able to sketch the intersection of the two fields on the cube, by writing down the steps, but students could not find the intersection of the two fields. Students cannot apply the theorem that the intersection of two planes can be a line. Through discussions between lecturers and students, the problems of the intersection of two fields in space can be in the form of points or lines Then the lecturer presented a picture and how to draw the intersection of two fields in a cube space as in Figure 4 below.

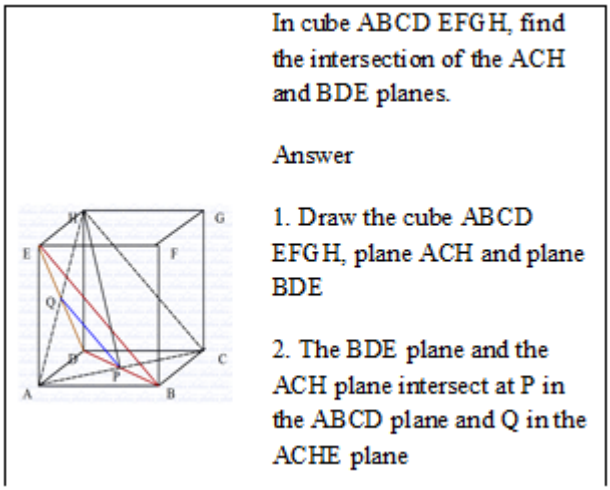


Figure 4. The intersection of the two fields in space.

3. In using symbols, ideas, structures and mathematical sentences from everyday problems, all subjects had no difficulty. However, the settlement was not in accordance with the appropriate strategy. Students solved problems that were not in accordance with the basic concepts being studied. Students did not use concepts that have been known in high school.

From the completion of students, information was obtained that in solving the problem, they were able to use the formula correctly and solve with the correct procedure, however solving the problem was not perfect, such as rationalizing the fraction of the root form. To find out the error, an interview was carried out, the results of the interview obtained information that students were not doing the rational form of the fraction of the form $\sqrt{\frac{3}{2}}$, because they considered the form of the number to be the simplest. The form $\sqrt{\frac{3}{2}}$, should be simplified to $\frac{1}{2}\sqrt{6}$.

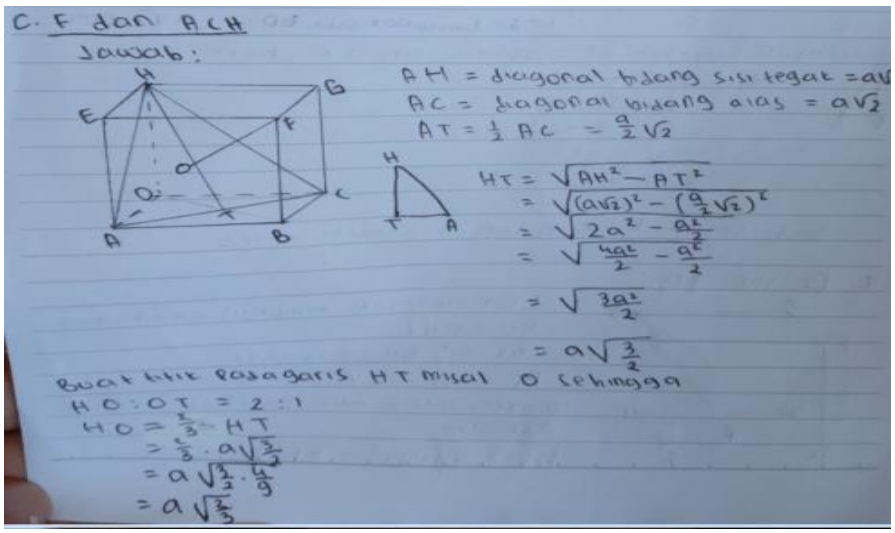
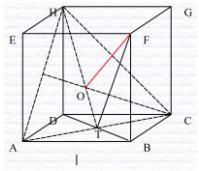


Figure 5. Rationalize the root shape

From the figure, it shows that students had difficulty finding the location of the line showing the distance of point F to the ACH plane and determining its length.

Through discussion with students, drawing the position of the point F distance to the ACH plane and determining the distance ware presented in Figure 6.



AH = diagonal bidang ADHE = $b\sqrt{2}$
AC = diagonal bidang ABCD = $b\sqrt{2}$
AT = $\frac{1}{2}AC = \frac{1}{2}b\sqrt{2}$

$$HT = \sqrt{AG^2 - AT^2}$$
$$= \sqrt{(b\sqrt{2})^2 - (\tfrac{1}{2}b\sqrt{2})^2}$$
$$= \sqrt{2ba^2 - \tfrac{1}{2}b^2} = \sqrt{\tfrac{3}{2}b^2} = \tfrac{b}{2}\sqrt{6}$$

OT = $\frac{1}{3}HT = \frac{b}{6}\sqrt{6}$
FT = HT = $\frac{b}{2}\sqrt{6}$
FO is the distance between the F and the ACH plane.

$$FO = \sqrt{FT^2 - TO^2} = \sqrt{\left(\tfrac{b}{2}\sqrt{6}\right)^2 - (\tfrac{b}{6}\sqrt{6})^2}$$
$$FO = \sqrt{\tfrac{3}{2}b^2 - \tfrac{1}{6}b^2} = \sqrt{\tfrac{8}{6}b^2} = \tfrac{4}{6}b\sqrt{3}$$

Thus, the distance between point F and field CH is equal to $\frac{4}{6}b\sqrt{3}$ cm

Figure 6. The distance between a point to a plane

4. To solve a problem, a formula or formulas with mathematical symbols in accordance with the problem and appropriate steps are needed to get the solution. The subject must be able to connect the appropriate formulas so that the solution was more effective. All subjects were able to choose and used symbols, mathematical ideas that were appropriate in the form of mathematical formulas and sentences to solve problems.

Discussion

From the results of documentation of student work and in-depth interviews of questions related to mathematical communication experienced by students, at the stage of mathematical communication ability the majority of students were able to receive question ideas and could write known elements and questions that were in accordance with the problem. However, students get deadlock in communicating between components into mathematical sentences using mathematical symbols that match the problem being solved. For students who can state communication between known components, these students can solve problems correctly. However, students with low abilities, especially those from non high schools majoring in natural sciences backgrounds, have a deadlock in finding solutions.

The results of this study are in accordance with research conducted by (**Hikmawati, 2018, P. 78)** concluded that subjects with high abilities have fulfilled all aspects of mathematical communication ability, namely aspects of writing, drawing and mathematical expressions. Subjects with moderate and low abilities are dominant in the aspects of writing and drawing and have difficulty expressing their mathematical ideas into aspects of mathematical expression. Other researchers (**Sari. 2015. p: 9**) showed that the symbols / notations written by high ability students were more numerous and more complete in writing mathematical communication on geometry questions for low ability students and

low ability students. An interesting finding is that: (1) all the subject has used the complete picture as a known description; (2) from one subject who writes the angle size with symbols / notations for example $m\angle ABC \cong m\angle PQR$; 3) there is one high ability student subject to write down all information using symbols / notations.

Mathematical communication ability for students is still low, as the results of research conducted by **Rustam (2017**), ”mathematical communication ability of coastal students in Kolaka Regency as a whole are still categorized as low. From another researcher (**Kumalaretna. W & Mulyono. 2017**), “mathematical communication ability can be seen that 27.78% of students are in the low category, 61.11% of students are in the medium category and 11.11% of students are in the high category” (p. 51).

In addition, Students' mathematical communication ability in the MEA learning model at SMP Negeri 3 Ungaran Students with high self-efficacy can use all indicators of mathematical communication to the fullest. Meanwhile, students with moderate and low self-efficacy have not been able to express mathematical ideas maximally (**Juhrani. 2017**).

The skill of using mathematical language both in writing and orally affects the mathematical communication ability of mathematics education students as prospective mathematics teachers. This is in accordance with the results of research conducted by **Gurafe (2018**), “it was found that prospective teachers could not use mathematical language adequately and their bases were unable to explain concepts using symbols and found some errors in using verbal language to explain concepts” (p. 670). To foster mathematical communication according to (**Viseu, 201**2) assumes that open tasks stimulate students to be involved in class activities, emphasizes the importance of teachers knowing how to listen to their students for encourage them to discuss class activities.

The results of this study can be concluded that written and oral mathematics communication as well as general public is still categorized as low for junior high school students, high school and university students. This is also in accordance with the research for mathematics education students of Faculty of Teacher Training and Education Pancasakti University Tegal, from the subjects selected by students who are not from high schools majoring in natural sciences, many have difficulty in mathematical communication, both written and oral communication. Besides that, the self-regulated learning of high schools majoring in natural sciencesstudents is better than the self- regulated learning of non high schools majoring in natural sciences students, this can be observed during face-to-face learning, students from high schools majoring in natural sciencesare more active, respond more quickly to problems and are quick to solve problems. For the completion of both online assignments and paper test assignments, there are still many non high schools majoring in natural sciences students who solve problems with income procedures. With the COVID-19 pandemic, students study at home more time to study independently, both individually and in groups of fellow students using online communication media. In selecting groups, the members are from high schools majoring in natural sciences and non high schools majoring in natural sciences. This is where an opportunity is needed with activities that help students with less abilities. Actually, the e-learning program is the right medium to help those who are weak. It only takes a struggle how weak students can show their responsibility which reflects that, the students who have high abilities will voluntarily help those who are less.

Conclusion

Student learning independence is needed to be able to carry out e-learning when looking for material, doing assignments, during discussion and evaluation. Through e-learning based self-learning, mathematical communication can be built through assignments and discussions both online and offline. Students' communication skills are analyzed using mathematical communication indicators. From the analysis of student work portfolios and interviews, it was found that good mathematical communication was the ability to use appropriate mathematical symbols to form formulas. Mathematical communication ability that need to be developed are: (1) the ability to plan an action in terms of writing down what is known and what is being asked; (3) the ability to use formulas in accordance with the study of the material; (3) the ability to manipulate problems into images, graphics or algebraic formulas; (4) the ability to determine the right solution strategy for each problem and (5) the ability to use the correct solution concepts and procedures in solving open questions.

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