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The Students' Mathematics Communication Skill Performance After GeoGebra-Assisted EPIC-R Learning Implementation

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Abstract. Mathematical communication is a fundamental skill needed by students. An application of ICT-based learning media, such as GeoGebra, using correct approach may increase mathematic communication. Therefore, this research aimed to analyze the effect of GeoGebra-assisted EPIC-R learning in improving students' mathematical communication skills. The study was sequential and explanatory research consisting of a sample size of 35 students from the Mathematical Education program at UIN Walisongo. The treatment class was treated using GeoGebra-assisted EPIC-R learning in geometry courses. Mathematical knowledge was observed from students' communication skills while explaining answers to an assignment and formative assessment. The GeoGebra and formative assessment were used as the X1 and X2 variables. Meanwhile, students' answers from the formative assessment worksheet, which consists of their communication level, are used as the Y variable. The results showed that the X1 and X2 variables significantly affected Y by 24%, which means that applying GeoGebra-assisted with EPIC-R learning increases students' understanding of geometry and mathematical communication skills. However, this research is limited by providing significant reasons why students provide incomplete and insufficient answers. Therefore, further studies need to be carried out to understand students' mathematical communication by observing their main problems in explaining solutions.

Keywords: cooperative learning; mathematical communication; geometry; problem-solving

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1. Introduction

Mathematics students are expected to properly deliver learning materials according to their developmental level to carry out effective mathematical communication (Makovec, 2018). This subject uses symbols and figures to convey and deliver concepts to the students (Rohid et al., 2019). In addition, they experience some challenges, especially in geometry. Mathematical communication is defined as interactions related to its problems, including the ability to express data, images, or situations using symbols, ideas, or models. Furthermore, the student also uses mathematical communication to explain these relations either orally or in writing, listening, discussing, and writing about the subject. Also, mathematical communication, including the ability to read and understand, written representations, and formulating conjectures, definitions, generalizing and restating a mathematical description in its language (Haji, 2019).

Mathematical communication that is not adequately developed impacts the students' understanding and lowers their learning achievement (Trisnawati et al., 2018). The Mathematics students are expected to convey mathematical concepts appropriately to help them learn and acquire a better understanding. One of the mathematic materials with a low delivery of Mathematical Communication is geometrical materials (Tiffany et al., 2017). Generally, solving these problems requires the use of drawings and appropriate steps to be easily understood. Meanwhile, explicit, systematic, and representative images help in problem-solving. Otherwise, inaccurate representation causes misinterpretation, which makes it difficult for students to solve specific issues. Learning geometry is fundamental because it leads to the development of Mathematical communication ability, which involves three types of cognitive processes: visualization, building ideas, and reasoning (Gera & Vijaylakshmi, 2015; Mujiasih et al., 2018).

Applying a common contextual approach in teaching increases writing skills, although not verbally (Qohar & Sumarmo, 2013). The obstacles encountered in using this procedure are caused by the students' unwillingness to present their concepts and ideas in a detailed and thorough manner. Meanwhile, expressing these arguments through mathematical communication aspect implies a comprehensive understanding of these concepts (Uygun & Akyüz, 2019). Constructing teachers' opinions are developed using appropriate learning media. It also provides opportunities for students to create an interactive environment (Hassan et al., 2016; Zhang & Liu, 2016). Information and communication technology (ICT) based learning media involves an interactive and practical session. This has been proven through using ICT-based media to aid students in applying concepts and procedures for solving mathematical problems (Daher et al., 2018; Sivakova et al., 2017; Tamur et al., 2020). Besides, it involves both visual and verbal communication abilities (Stanojević et al., 2018). This is supported by sharpening students' abstract ideas through experiences, prediction, interaction, communication, and reflection (EPIC-R) learning model. According to Abed et al. (2015), it aids in conveying their ideas on geometry through an analogical process. Meanwhile, teachers are expected to adopt ICT-based media to strengthen visualization in EPIC-R learning, including GeoGebra. The application of this concept aids in developing students' mathematical communication skills in visualizing their ideas. Utilizing clear-cut GeoGebra and algorithms is also expected to provide systematic solutions. As a synthesis, this research is aimed to analyze the effect of GeoGebra-assisted EPIC-R learning in improving students' mathematical communication.

2. Literature Review

The core of EPIC-R learning activities is presented in five brief explanations, including gaining experiences, developing practical skills, creating active, interactive sessions, mathematic communication, and reflection. This approach is a modified contextual learning model that is focused on improving concept development and ideas. Mathematical communication is a fundamental prerequisite for long-time experiences and knowledge (Kaya & Aydin, 2016). It aids in resolving the difficulties encountered by the students in building communication styles. Therefore, this model highlights activities that enhance their expertise in creating experiences, data-based argument, interactive and elaborate ideas, and reflect on the materials. Therefore, this study was based on experiences, prediction, interaction, communication, and reflective activities.

2.1. Gaining Experience

The development of mathematical concepts in literature is inseparable from the adaptation and addiction of the learning process that can be gained by active experiences. The student's experiences in physical, emotional, and cognitive interactions make the learning technique in mathematics become easier (Khosrotash & Alhosseini, 2019; Pickard-Smith, 2021). The learning of mathematics directly creates long-term memory that helps students develop certain concepts. The outcome serves as primary data in making independently developed predictions, which affect the perception of the material being studied. However, solving math problems undoubtedly affects the emotions and feelings that tend to occur (Hernandez-Martinez & Vos, 2017). Therefore, this study facilitates students to experience the reasoning process by searching and discovering existing settlement strategies on the source problem both independently and by investigating. It simply means that mathematics learning does not only focus on the learner's cognition, rather it also creates positive emotions (Martínez-Sierra & García-González, 2016)

2.2. Developing Prediction Skill

Mastery of mathematical concepts leads to the development of predictable and reliable analysis and logical thinking skills. This well-formed process provides the basis for solving mathematical problems. The predictive learning strategy assists in uncovering misconceptions through a schema based on validated knowledge (Lim et al., 2010). In addition, this approach uses literacy skills to obtain information which aids in making accurate and accountable predictions (Peterson et al., 2017). Indeed, this technique has been existent in mathematical problem-solving and learning. Therefore, the students' expectations of these abilities provide an overview of conceptual understanding and encourage meaningful materials knowledge. In addition, it is more vital with cooperative and collaborative learning models because it requires a consensus from the students (Schoevers et al., 2020).

2.3. Creating Active Interaction

Interactive activities are usually common during the teaching and learning process. Its occurrence among students is facilitated by carrying out knowledge transfer and exchanging ideas in groups to realize an elaborate concept (Bossér & Lindahl, 2019; van de Pol et al., 2019). These activities involve testing predictions, formulating agreements, and discussing reports. The exchange of ideas is the active sharing of knowledge with others. It boosts integration among students, which has also been proven to help them focus on learning activities, explore new understandings, and creating an existing learning environment (Ahmad et al., 2017; Sumirattana et al., 2017; Van Zoest et al., 2017). Nevertheless, interaction needs to be directed in a suitable and favorable corridor.

2.4. Presenting Mathematical Communication

Communication is the primary means of conveying and exchanging ideas, including the learning process. However, for prospective mathematics teachers, especially undergraduates, this skill is not limited to dialectics. Rather, it also involves presenting and interpreting symbols, data, and images, thereby enabling its quick implementation (Pantaleon et al., 2018). This is related to the role of the teacher in achieving both professional and learning goals. Strengthening student communication skills are essential and prepare them to become experienced teachers (Maulyda et al., 2020).

Learning mathematics aids in developing students writing and verbal skills, especially those related to symbols and solutions to visual and verbal representations (Rusyda et al., 2020). The students are expected to apply various forms and models of communication in generating and sharing ideas. Evaluating these styles certainly helps to analyze their abilities to convey specific ideas to obtain a comprehensive picture of conceptual understanding. Therefore, in this research, foundation students share their experiences, predictions, and interactions communicated mathematically in solving problems.

2.5. Conducting a Reflection

Reflection in learning is characterized by one’s ability to re-learn, study and conceptualize the acquired knowledge to boost understanding. It is usually performed at the end of the process and serves as a strategy for achieving new ideas (Chang, 2019). This is a critical stage because reflecting on the learning activities help students to behave. In addition, it is carried out individually and evaluated as a group by comparing different strategies or ideas. The advantage gained from the reflection model is that it helps to understand the problem from various perspectives and supports the enhancement of software capabilities (Bature, 2020). In mathematics, reflection is also related to efforts to bridge mathematical problems' theoretical state and results (Breda et al., 2017). Students are able to understand and improve the concepts from various perspectives. In this study, they reflect on the learning experiences obtained either in groups or individually guided by two questions, namely 1) what concepts have been learned? and 2) how can what has been learned be applied? Besides, through reflective activities, it is hoped that relevant and robust mathematical concepts are formed.

3. Method

This research adopted a mixed-method sequential explanatory approach designed by Creswell (2009). The quantitative aspect involves 35 students from Mathematics Education Study at the Faculty of Science and Technology, Universitas Islam Negri Walisongo, Semarang City, Central Java, Indonesia, that takes Geometry courses. In addition, the experimental class was randomly selected and given EPIC-R learning treatment assisted by GeoGebra. Mathematical knowledge and communication were performed by pre and post-tests. Fortunately, the pre-test scores were obtained from individual assignments and used as an X1 variable. On the contrary, the post-test scores were realized from formative assessments and presentations. The correct answers were calculated and expressed as an X2 variable.

The students' work description on the formative assessment worksheet was assessed based on the scoring indicator for mathematical communication skills used as a Y variable, as shown in Table 1. It was also used to categorize students' skills into three groups low, middle, and high skilled. Furthermore, the data were analyzed using a one-sample t-test with a classical completeness reference value of 71.00, referring to the Indonesian minimum completeness standard. The effect score was measured using regression analysis and was statistically reviewed using SPSS var.23.

The questions asked in the initial and final assignment need to comply with the guidelines in the research carried out by Viseu and Oliveira (2012). The approach includes 1) disclosed mathematical communication skills using open-ended model questions. 2) an existent correlation exists between the problems, including the solution strategy, and 3) fluency or flexibility in nature, which have non-single correct answers or questions solved using various models.

Therefore, interviews confirmed its influence on mathematical communication ability, which revealed the students' proficiency in verbally explaining written ideas. Meanwhile, three of them were randomly selected from the high, middle, and low skilled groups in a qualitative approach. An in-depth interview was carried out to diagnose the growth of the mathematical communication skill on each of the six indicators, namely 1) the informed value, 2) depict geometric abstraction, 3) generate new information from the acquired data or value, 4) holistic problem-solving, 5) adding related concepts, and 6) drawing an appropriate conclusion.

These were used to systematically discover the students' problems and solutions, accompanied by communicative presentations performed with the appropriate language using GeoGebra software media. The mathematical communication growth indicator, classified into four criteria by Haji, (2019), is shown in Table 1.

Table 1: Mathematical communication growth criteria

Criteria	Code*	Mathematical Communication Growth Indicators
Excellent	E1	Presents correct, complete, and precise information about data acquired from the question or problems.
	E2	Draws an apparent geometric abstraction of the main problem and proposed solution.
	E3	Writes the correct and holistic informed information systematically generated from the available data.
	E4	Clearly, correctly and systematically completes the whole problem-solving procedure.
	E5	Informs related and represented concepts correctly.
	E6	Presents relatable and straightforward conclusion
Good	G1	Presents correct and complete although unclear information about the data acquired from the question or problems
	G2	Clearly presents problems in the form of geometric drawings,
	G3	Writes the correct although incomplete informed data generated from the provided value.
	G4	Clearly, correctly and systematically completes specific problem-solving procedures.
	G5	writes related concepts correctly, although not precisely.
	G6	Presents complete and unclear conclusion.
Moderate	M1	Writes down both untrue and true incomplete information
	M2	Presents the problem in the form of an incomplete and unclear geometric drawing
	M3	Writes the correct and incomplete value.
	M4	Presents solving procedure, both incorrect or correct. However, the majority of the given information is incomplete.
	M5	Write down related and wrong concepts.
	M6	Presents preliminary and unclear conclusions.
Bad	B	The bad criteria are given when the answer is inappropriate, as indicated by six indicators generated from the 3 criteria.

Note: *The first letter of the codes represents the criteria, E = excellent, G = good, M = moderate, and B = bad. The followed number after the alphabet represents the indicator achievement.

4. Result

4.1. Ability to Complete Geometric Assignments and Mathematical communication

The analyzed results prove that applying the GeoGebra-assisted EPIC-R learning model in the geometric material effectively increases mathematical communication in the experimental class. However, there was an insignificant decrease in the assessment score (Table 2). The initial results also show that the students developed mathematical communication abilities, enabling them to skillfully solve problems, especially in geometry.

Table 2: The value of the initial and final assignment of learning.

Assignment	Min	Max	Mean	SD	SE
X1	73	93	82.138*	5.981	1.111
X2	74	92	80.345*	4.616	0.857

Note: Sign (*) indicates the variable has a significant mean > 71. X1 = pre-test score, X2 = post-test score. Min = minimum score of the test. Max = maximum score of the test. SD = Standard deviation. SE = Standard error.

This study also shows the effect of initial assignment (X1) and formative assessment (X2) on mathematical communication skill (Y), as indicated by the regression analysis value (Table 3).

Table 3: Results of the regression analysis of the assignment relationship on mathematical communication abilities

Model	R	R^2	Adjusted R^2	SE
X1+X2 → Y	0.490[a]	0.240	0.182	3.43594

Note: The uppercase letter a indicates the Predictors: (Constant), X2, X1. R represents regression score. X1 = pre-test score, X2 = post-test score. Min = minimum score of the test. Y = mathematical communication score. SE = Standard error.

The effect of learning strategy on mathematical communication skills shows a strong and positive correlation. The coefficient of determination of the assignment and test result abilities on the mathematical communication (R2) score is 24%. Even though other factors probably dominate, approximately 76% affect the students' skill in communicating their ideas on geometry problem-solving.

Interestingly, this study reveals that an initial assessment, followed by individual assignment and formative evaluation after applying the GeoGebra-assisted EPIC-R learning, contributes to the students' mathematical communication development. The regression analysis indicates a significant influence on the test results (X1 and X2), as shown in (Table 4).

Table 4: ANOVA test results for variables X1 and X2 against Y

Model		Sum of Squares	df	Mean Square	F	Sig.
X1+X2 → Y[a]	Regression	96.915	2	48.457	4.105	0.028[b]
	Residual	306.947	26	11.806		
	Total	403.862	28			

Note: The uppercase letters (a) indicates dependent Variable; and (b) indicates Predictors: (Constant), X2, X1: R represents regression score. X1 = pre-test score, X2 = post-test score. Min = minimum score of the test. Y = mathematical communication score. SE = Standard error. F = F value. Sig. = significant value above 0.050

However, individually, the initial assignment (X1) and the formative assessment (X2) did not show any significant influence on mathematical communication (Y), as shown in Table 5. This is possible because the positive impact percentage of each variable in increasing the mathematical communication ability value is relatively as low as 21.3% and 21.4% for X1 and X2, respectively. These results do not represent mathematical communication abilities.

Table 5: The effect of initial assignment and final assessment on student's mathematical communication skill

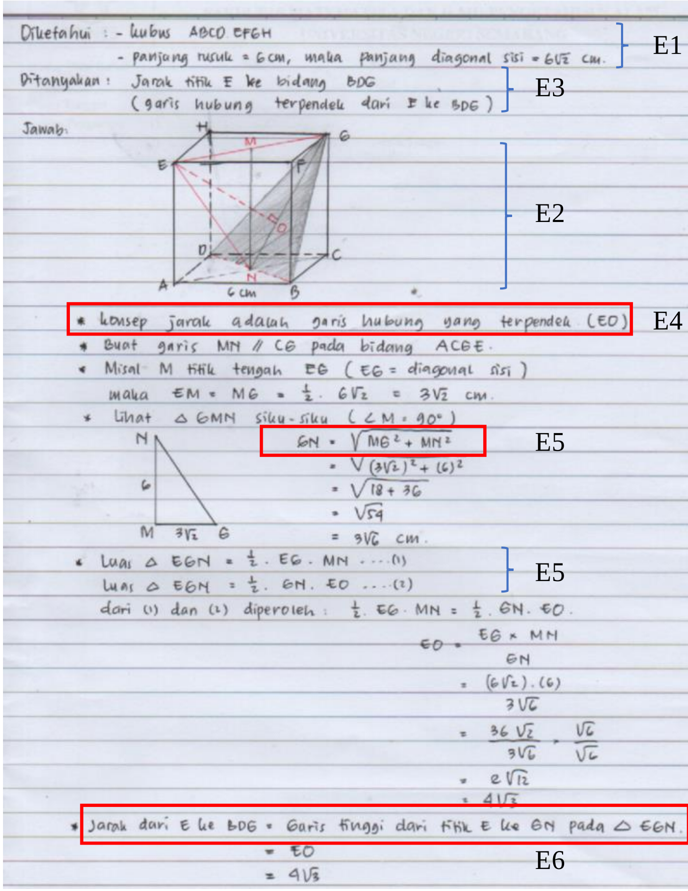
Model		Unstandardized Coeff.		Standardized Coeff.	T	Sig.
		B	Std. Error	Beta		
X1+X2 → Y	(Constant)	44.411	12.482		3.558	0.001
	X1	0.213	0.116	0.335	1.835	0.078
	X2	0.214	0.150	0.258	1.409	0.171

Note: The value of the constant model is calculated using the following regression equation $\hat{Y} = 44.441 + 0.213X1 + 0.212X2$. $\hat{Y} = 44.441 + 0.213X1 + 0.212X2$. X1 = pre-test score, X2 = post-test score. Y = mathematical communication score. SE = Standard error. T = T value. Sig. = significant value above 0.050

4.2. Student's mathematical communication skill analysis

The students' mathematical communication skill is assessed by analyzing, observing, and evaluating individual assignment results, presentations, final test outcomes, and interviews. Completion of these tasks receives feedback or reviews from lecturers, which call for improvement in subsequent ones. The analysis of students' answers on both the initial ability test (X1) and the formative assessment (X2) did not indicate that they encountered any obstacles to understanding the geometric concept. The main problems encountered are generally due to inaccuracy and time to finish the tasks efficiently.

The students' mathematical communication skill was analyzed based on the answers provided for the test questions with a moderate level of difficulties according to predetermined indicators (Table 1). Meanwhile, three of the students were selected as interviewees to represent the formative assessment classified groups. Their worksheets were further evaluated and confirmed to determine the extent to which mathematical communication skills were developed, as shown in Figures 1 to 3.



Transliteration

Informed: cube ABCD EFGH
: edges length = 6 cm, then face diagonal = $6\sqrt{3}$ cm
Questioned: distance from E vertex to BDG side
: shortest length from E vertex to BDG side
Answer:

Distance concept is a shortest connector line (E to O point)
Create a MN // CG line on ACGE plane
M is middle point of EG (EG = edge diagonal)
So, $EM = MG = \frac{1}{2} \times 6\sqrt{2} = 3\sqrt{2}$
Look at ΔGMN is a right triangle ($\angle M = 90°$)
$GN = \sqrt{MG^2 + MN^2}$

The wide of $\Delta EGN = \frac{1}{2}. EG. MN$...... (1)
The wide of $\Delta EGN = \frac{1}{2}. GN. EO$....... (2)
From (1) and (2) equation, got $= \frac{1}{2}. EG. MN = \frac{1}{2}. GN. EO$

The distance from E vertex to BDG side = High line from E vertex to GN edge on ΔEGN

Figure 1: Student answer worksheet in high mathematical communication skills. The answer indicators are marked with a red box and blue bricks. The code E1-E6 representing mathematical communication skill criteria

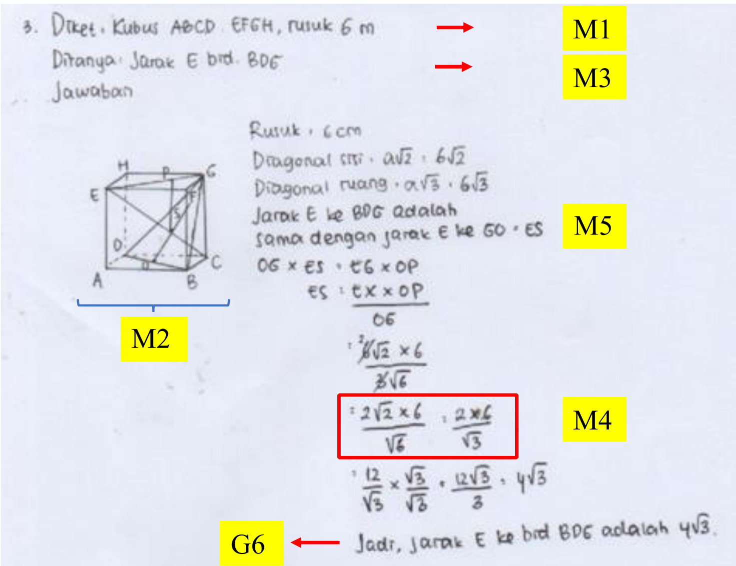
The student's worksheet indicates a complete mathematical communication skill indicator with excellent criteria. Generally, all popped up to complete the sentences. However, the mathematical communication skill was described narratively based on the student's worksheet for more understanding, as shown in Table 6.

Table 6: Mathematical communication skill description from the student with high score performance

Code*	Results of Mathematical Communication Skill Analysis
E1	S1 expresses mathematical problems or situations using symbols. In the known part, S1 writes correctly and completes the information concerning the diagonal length of the sides. S2 properly mapped the commonalities of identified problems.
E3	S1 was able to clearly and completely identify the questions related to the concept, namely the shortest link.
E2	Problem-solving ideas are shared through the correct and complete cube image, while BDG fields are clarified with shaded areas. In addition, an auxiliary plane is created in the form of an EGN, and GMN triangles, including an MN line to determine the distance from

	point E to the BDG plane. S1 was able to apply visual similarity relationships to the problems faced by solving the task using GeoGebra.
E4-E5	At the completion step, S1 was able to state the idea clearly. The settlement procedure is represented by applying several related concepts, namely the definition of the midpoint, rectangular property, Pythagorean theorem, formula for the area of a triangle, and the transitive nature of the equation. The completion strategy applied by S1 refers to the similar approaches that were mastered during the assignment. In addition, S1 carried out the evaluation and abstraction process based on the similarities between the tasks and test questions. Therefore, S1 was able to provide systematic solutions and make conjectures in their language.
E6	S1 generalized solutions by stating that the height of a triangle is the distance from point E to the BDG plane.

Note: *The first letter of the codes represents the criteria, E = excellent, G = good, M = moderate, and B = bad. The followed number after the alphabet represents the indicator achievement.



Transliteration

Informed: cube ABCD EFGH, 6 cm of edges

Questioned: distant from E vertex to BDG side

Answer:

Edges = 6 cm

Face diagonal = a$\sqrt{2}$ = 6$\sqrt{2}$

Cube's space diagonal = a$\sqrt{3}$ = 6$\sqrt{3}$

Distance from E vertex to BDG side is?

Equal to the distance of E vertex to the BDG side = ES

So, the distance from E vertex to the BDG is 4$\sqrt{3}$

Figure 2: The student's answer worksheet from the middle group of mathematical communication skills. The answer indicators are marked with a red box and blue bricks. E1-E6 representing mathematical communication skill criteria.

Irrespective of the fact that the students' answers were systematically arranged and all indicator was mentioned, different from those that scored high, most of those categorized in the middle score group had incomplete sentences or information. For more description, the evaluation of the student's worksheet is shown in table 7.

Table 7: Mathematical communication skill description from the student with middle score performance

Code*	Results of Mathematical communication Ability Analysis
M1	S2 was able to express mathematical problems or situations using symbols. The information gotten from the question was added to the solution strategy section. S2 properly mapped the problem identification similarities.
M3	S2 also clearly identified the problem, irrespective of the fact that they do not know that distance is the shortest line.
M2	The solution strategy is represented by the correct, although less precise and incomplete, cube image. This is evident in the frontal plane, which is not presented in a square shape. The idea is also not equipped with a triangular plane to clarify the ES length reasons. In addition, S2 does not complete the ACGE auxiliary plane, and the line is parallel to AE or CG, therefore it is unable to provide a reason for getting a length of OG = $3\sqrt{6}3\sqrt{6}$.
M5	S2 clearly stated the complete steps although, they are not equipped with related concepts. This results in a mismatch related to the assumption that ES is a high line and the calculated process involves irrational numbers.
M4	The incomplete and inaccurate settlement strategy is due to the inability of S2 to isolate the structure shared in solving the assignments with the test questions.
G6	S2 tends to properly draw conclusions, although it is not supported by complete evidence and reasons.

Note: *The first letter of the codes represents the criteria, E = excellent, G = good, M = moderate, and B = bad. The followed number after the alphabet represents the indicator achievement.

A significant difference was observed from the 3 sample student's worksheets from various groups. However, those in the low score group presented a distinctive and incomplete answer, which is correct (Figure 3). It also relates to the students' level of patience and diligence in finishing their work. However, it needs to be evaluated to reveal the main factors affecting students' mathematical communication skills.

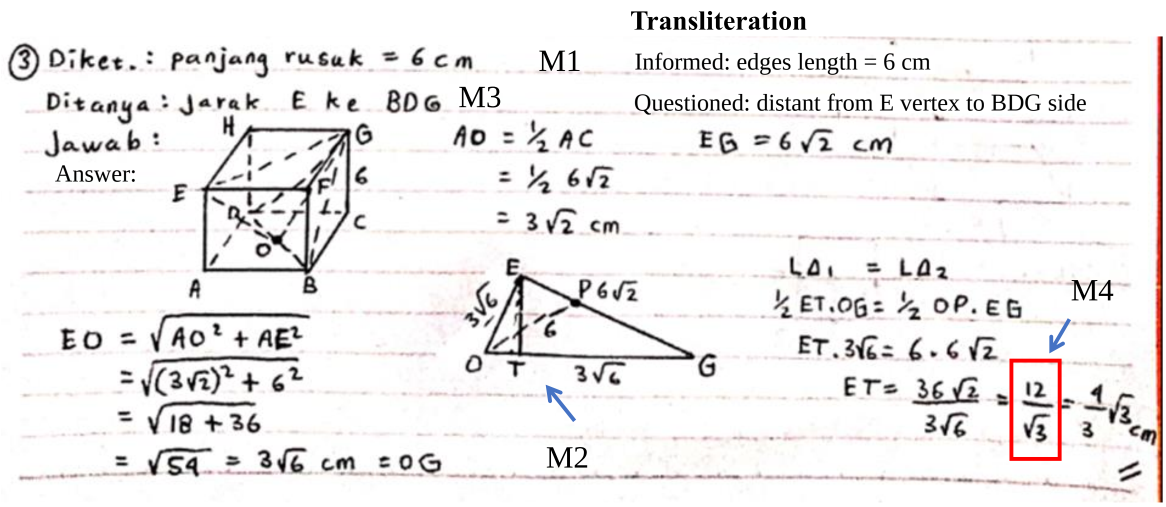


Figure 3: Student answer worksheet from the low group of mathematical communication skills. The answer indicators are marked with a red box and blue bricks. The code E1-E6 representing mathematical communication skill criteria.

Based on the analysis, there were 2 indicators with bad criteria: 1) no related concept to help strengthen and explain their answers, and 2) inappropriate presentation to draw a conclusion. The student worksheet analysis was described as shown in Table 8.

Table 8: Mathematical communication skill description from the student with low score performance.

Code*	Results of Mathematical Communication Ability Analysis
M1	S3 incompletely conveys relevant information from the problem. S3 only mentions the length of the ribs without giving the name of the spatial shape. S3's ability to map commonalities in problem identification is still not good.
M2	The image representation shown by S3 is not entirely accurate. Even though the frontal plane is square, the incorrect orthogonal line length caused the depicted space to resemble a block rather than a cube. Additionally, the OEG auxiliary image is also false. It does not include the ACGE auxiliary planeS3, which represents the OEG and isosceles triangle, besides OE and OG's lengths are different. The errors and inaccuracies made by S3 were caused by the inability to map the similarities between the assignment and test questions.
M3	S3 can identify the question being asked however, S3 is not equipped with the fact that the distance is the shortest line
M4	At the final stage, S3 failed to determine the properties of the ACGE rectangle. This led to the reason, S3 was unable to ascertain that length OP is 6 cm. In applying the formula used to calculate the area of a triangle, S3 also failed to include the concept of transitive properties. This weakness causes an error in stating the equation for the area of triangle EOG, which does not need to be represented as 2 triangles. S3 was also not careful in calculating rationalizing radical numbers. Therefore, the final result is incorrect.
B	At the final stage of completion, S3 was unable to draw conclusions through the generalization of solutions.
	Identifying the evaluation process shows that S3 was unable to isolate its structure in solving the assignments and test questions. This is the reason S3 experienced several errors and the inability to state the arguments.

Note: *The first letter of the codes represents the criteria, E = excellent, G = good, M = moderate, and B = bad. The followed number after the alphabet represents the indicator achievement.

Several students experienced low mathematical communication growth. This was caused by weaknesses in 1) using symbols and numbers to present the idea visually, clearly, and communicatively, 2) adopting correct and communicative resolution steps, and 3) linking the problems faced with those that have been resolved. The process that inhibits these weaknesses is related to identifying and isolating shared commonalities, as well as deciding on a strategy based on the similarities between the problems at hand and those experienced.

5. Discussion

In this study, the application of GeoGebra-assisted EPIC-R learning significantly boosted mathematical communication skills. Its use during presentations and to directly solve assignments helps train students to express themselves orally, thereby deepening their understanding of geometric concepts. Meanwhile, during presentations, some others gave excellent responses. This boosts their confidence and effort to deliver at subsequent productions. GeoGebra media also improves the students' mathematical communication abilities during some presentation activities, especially in explaining ideas (Jelatu et al., 2018). This is important because it helps student to convey related concepts appropriately (Yang et al., 2016).

The development of this skill is observed from the students' performances and complexities in answering questions during the evaluation process. This includes the mapping technique, which solves the problem by linking commonly experienced issues (Lovett & Forbus, 2017). Abstraction is the process of isolating structures from the problem at hand (Fitriani et al., 2018). Meanwhile, the evaluation process is an activity used to determine the completion strategy. The students have been trained on ways to apply the EPIC-R learning through assignments.

EPIC-R application in this research contributes to the reasoning activities as well as develops the students' thinking skills by solving problems based on various perspectives (Joyce et al., 2011; Pourdavood & Wachira, 2015). The reasoning involved in the application of EPIC-R learning to foster mathematical communication is evident in the activity of student analogical abilities, which includes 1) describing the geometric problems visually, logically, and systematically, 2) develop analog problem-solving strategies, isolate similarity in structure, and explore the problems at hand, 3) suggest various ways to solve problems commonly faced, 4) determine the settlement strategy based on similarities, and 5) draw conclusions based on the type of analogy adopted.
However, it is undeniable that certain factors also influence students' mathematical communication abilities, including anxiety, lack of written knowledge or concepts, and the inability to link images with the given explanations (Lomibao et al., 2016; Vale & Barbosa, 2017). In this study, they were not examined, and it was assumed that students did not experience anxiety when communicating the results of their work. In addition, they have been trained to adopt good strategies, and the majority adopted correct steps in solving geometric problems. According to Freeman et al. (2020), the application of GeoGebra applications in this study also proves that technology helps to improve the students' ability to communicate ideas. Therefore, the use of GeoGebra in solving problems is also one factor that affects the growth of Mathematical communication skills, especially orally.

In general, the student focus on understanding concepts and rarely focus on conveying these ideas efficiently. Güçler (2014) stated that using graphics, symbols, and notations to explore ideas plays a vital role in improving Mathematical communication ability. Therefore, this research also applied EPIC-

R learning to support or facilitate students' Mathematical communication skills (Abed et al., 2015). They are continuously trained in proving theorems, discussing materials, and solving problems to ascertain their growth. Rohid et al., (2019) stated that mathematical communication, created from four strategies are needed, namely, (1) providing a lot of assignments or exercises, (2) seeking a comfortable environment for students to work, (3) providing opportunities to explain ideas and clarification by the teacher, and (4) directing the learners to process ideas independently.

Students' mathematical communication skills are effectively developed through continuous assignments. This allows them to provide answers verbally, which contributes to their mastery of visual representations and development (Maulyda et al., 2020). Discussion activities among them also deepen their understanding of these concepts. Furthermore, the growth of better mathematical communication impacts the students' affective aspects in taking geometry courses. This is indicated by motivation, interest in learning, and self-confidence, during lectures. Additionally, mathematical writing activities are a way to explain their ideas in completing assignments and making presentations. Bicer et al. (2011) stated that the strategy to foster communication in algebra and geometry improves mathematical writing skills. Training students in this aspect also helps them develop problem-solving techniques to generally increase procedural knowledge and cognitive abilities (Cragg et al., 2017; Temple & Mohammed, 2020).

Specifically, expressing ideas is done by training students to represent images thoroughly and systematically. Interactions with others allow them to significantly reflect on concepts and elaborate on their knowledge when solving problems together (Lee, 2006). The process of arranging terms requires guidance from the teacher because symbols produced by students tend to have different meanings (Godino et al., 2007; Güçler, 2014). This plays an essential role in improving mathematical communication ability, although sometimes, it indicates process and object (Güçler, 2014). The teacher uses various strategies to create discussions to make it easier for students to express ideas that involve these symbols. Mathematics education students, and student, likely represent the same notation, although they are expressed differently, thereby indicating the occurrence of miscommunication. Therefore, students' involvement in composing symbols and mathematical meanings is significant and allows them to interpret these symbols in mathematical problems.

6. Conclusion

Applying the GeoGebra-assisted EPIC-R learning model by students of the Mathematics Education Program effectively correlates with increased communication ability. They are able to link basic knowledge with the known and acquire information and algorithms by utilizing GeoGebra as a medium for communicating mathematical ideas. This trains the students' Mathematical communication ability verbally and non-verbally. Although accuracy in solving issues is necessary, communicative problem solving is also significant for the student. It requires answering correctly, including pictures and reasons for decoding, and providing complete solutions steps. Mathematical, verbal communication is shown through presentation skills, discussion, or question and answer.

This study only focuses on the role of implementing GeoGebra-assisted EPIC-R learning. Observations of student barriers in carrying out the analogy process have not been carried out in-depth. This is the reason the solution to overcome the low mathematical communication skills of students caused by difficulties in making analogies was not identified. Analysis of the barriers encountered is recommended as the basis for determining a more appropriate learning method. Furthermore, students' responses and the impact of EPIC-R learning on affective aspects also need to be evaluated to develop a more practical application of the EPIC-R process.

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