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Analysis of Students' Mathematical Communication Skills in Solving Problems Assisted by the *Symbolab* Application

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ABSTRACT

Mathematical communication skills are essential in enabling students to express mathematical ideas through symbols, models, and visual representations. However, many Indonesian students still experience difficulties, particularly when solving story-based problems. This study aimed to analyse students' mathematical communication skills in solving linear programming story problems using the *Symbolab* application. The research employed a descriptive qualitative design involving 32 tenth-grade students at Madrasah Aliyah Swasta Plus Al Ulum Medan. Data were collected through five story problems and follow-up interviews with selected students representing each ability level. The result showed that 37,5% of students were in the low category, 37,5% in the medium category, and 25% in the high category of mathematical communication skills. Most students had difficulty translating story problems into mathematical models, which led to errors in graph construction, shading region determination, and final computations. Although the *Symbolab* application helped students visualise graphs and follow solution steps, students still had to construct mathematical models from the problems independently. These findings suggest that while the *Symbolab* application can support visualisation and solution steps, explicit instruction and practice in translating word problems into mathematical models remain crucial for developing students' mathematical communication skills.

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1. INTRODUCTION

The Merdeka Curriculum, introduced by the Ministry of Education, Culture, Research, and Technology of Indonesia, aims to create a learning environment that is more adaptive and responsive to the diverse needs of students at all levels of education [1] [2]. Another learning objective of the Merdeka Curriculum is enable students to communicate concepts through symbols, tables, diagrams, or other media by describing conditions or problems and expressing situations in the form of mathematical symbols or models [3]. Therefore, communication skills in mathematics learning are crucial. These skills support the teaching and learning process and facilitate the exchange of ideas between teachers and students as well as among students themselves. NCTM [4] states that mathematical communication is the conveyance of mathematical ideas through various forms, such as oral expression, writing, drawings, diagrams, the use of objects, algebraic expressions, and mathematical symbols. Developing strong mathematical communication skills is important because these skills greatly influence the student learning process. When students are challenged to communicate their thinking to others, either orally or in writing, they learn to be clear, precise, and persuasive in their use of mathematical language [5]. When students possess good mathematical communication skills, they can provide appropriate responses during interactions with peers and teachers in the learning process [6]. The explanations students provide should include mathematical reasoning and arguments, rather than merely procedural descriptions or summaries. Listening to others' explanations gives students opportunities to develop their own understanding, while discussions in which mathematical ideas are explored from multiple perspectives help participants refine their thinking and make meaningful connections [7]. In addition, this ability enables students to create various representations [8], making it easier for them to choose appropriate strategies for solving mathematical problems.

Preliminary observations were conducted to examine students' mathematical communication skills in class X-1 at Madrasah Aliyah Swasta Plus Al Ulum. This observation involved 32 students who were given two story problems. The result showed that students' mathematical communication skills in solving story problems still need improvement. As many as 79% of students experienced difficulties in explaining their thinking using symbols and diagrams.

One factor contributing to students' low mathematical communication skills in solving story problems is the limited use of technology-based learning media. One technological tool that has developed rapidly is AI (Artificial Intelligence)-based learning media, including the *Symbolab* application. *Symbolab* is a tool used in advanced mathematics that allows users to learn, practice, and obtain step-by-step solutions using mathematical symbols and notation [9]. This application can help students learn by providing answers along with explanations of solution steps [10].

Previous studies have shown positive results for *Symbolab*. Research [11] reported improvements in students' mathematical communication skills and learning independence through the Team-Assisted Individualisation (TAI) model, supported by the *Symbolab* application. Qurohman [12] also found that Symbolab use significantly improved students' understanding of complex mathematical concepts. Based on these studies, it can be concluded that the *Symbolab* application has the potential to support students' mathematical development. Therefore, this study aims to analyse students' mathematical communication skills in solving problems using the *Symbolab* application.

2. METHOD

This study employed a descriptive qualitative research design. The research instruments consisted of a written test and follow-up interviews with selected students. The study was conducted in a natural classroom setting, where students used Android devices to access the *Symbolab* application through Google Chrome. Data were collected directly from participants and analysed descriptively to describe students' mathematical communication skills in problem-solving assisted by the *Symbolab* application.

The researcher administered five story-problem questions on linear programming material to 32 students in class X-I at Madrasah Aliyah Plus Al Ulum Medan during the 2024/2025 academic year. Students were allowed to use the *Symbolab* application while solving the problems. The application helped students perform numerical procedures and visualise graphs; however, students still had to translate the story problems into mathematical models independently.

Students' answers were assessed based on indicators of mathematical communication skills. Each indicator was scored, and the total scores were categorised into three levels of mathematical communication ability: low, medium, and high. The indicators of mathematical communication skills and the classification of ability levels are presented in Tables 1 and 2.

Table 1. Indicators of Students' Mathematical Communication Ability on Linear Program Material

Indicators of Mathematical Communication Ability	Score
Students can write ideas in the form of mathematical symbols	15
Students can write the appropriate mathematical model of the story problem	15
Students can draw graphs to determine the solution area according to the equation that has been formulated	15
Students can explain the idea of a linear inequality form to determine the direction of the graph shading	15
Students can solve the final problem correctly	15

Table 2. Categories of Mathematical Communication Ability Levels

Score Limit	Categories of Student Mathematical Communication Ability Levels
$N < 65$	Low
$65 \leq N \leq 80$	Medium
$81 \leq N \leq 100$	High

Description:
N = Student's final score

The final score in solving five story problems can be obtained through the following formula.

$$N = \frac{\text{Total score obtained}}{\text{Total score}} \times 100 \quad 1)$$

After categorising the results, three students representing each level of mathematical communication ability were selected for interviews. These interviews aimed to explore the reasons behind students' errors and difficulties in solving the story problems.

3. RESULTS AND DISCUSSION

3.1. Results

Based on an analysis of 32 students' test results, three categories of mathematical communication ability were identified in solving story problems: low, medium, and high. The findings revealed that an equal number of students fell into the low and medium categories. From these categories, the researcher selected three student representatives-one from each level- for in-depth analysis. The following tables present the distribution of scores and categories of mathematical communication ability levels, as well as detailed performance indicators for the three selected students.

Table 3. Scores and Categories of Mathematical Communication Ability Levels

Score Limit	Categories of Mathematical Communication Ability Levels	Number of Students	% Students
$N < 65$	Low	12	37,5%
$65 \leq N \leq 80$	Medium	12	37,5%
$81 \leq N \leq 100$	High	8	25%

Table 4. Mathematical Communication Ability of Students in Problem Solving using *Symbolab* Application

Subject	Indicator of Mathematical Communication Ability	Problem Solving		
		No Solving	Making Little Solving	Making Correct Solving
S1	Students can write ideas into mathematical symbols			√
	Students can write mathematical models from story problems.		√	
	Students can draw graphs to determine the solution area for the equation formulated.	√		
	Students can explain the idea of a linear inequality form to determine the direction of the graph shading.	√		
	Students can solve the final problem correctly.	√		
S2	Students can write ideas into mathematical symbols.			√
	Students can write mathematical models from story problems.			√
	Students can draw a graph to determine the solution area according to the equation formulated.		√	
	Students can explain the idea of a linear inequality and use it to determine the direction of the graph shading.		√	
	Students can solve the final problem correctly.	√		
S3	Students can write ideas into mathematical symbols.			√
	Students can write mathematical models from story problems.			√

Subject	Indicator of Mathematical Communication Ability	No Solving	Problem Solving Making Little Solving	Making Correct Solving
	Students can draw a graph to determine the solution area according to the equation formulated.			√
	Students can explain the idea of a linear inequality form to determine the direction of the graph shading.			√
	Students can solve the final problem correctly.		√	

3.2. Discussion

The analysis of Table 4 reveals that S1 (low-ability student) encountered significant obstacles when solving story problems in linear programming. Despite having access to Symbolab, this student faced persistent challenges. S1 successfully wrote ideas, attempting to formulate mathematical models that aligned with the problem's requirements. This initial modelling difficulty created a cascade effect, preventing the student from completing subsequent steps in the problem-solving process. The *Symbolab* application could be effectively used only after students successfully created accurate mathematical models; these models were then used to generate graphical representations, determine shading directions, and find intersection points between lines.

The interview with S1 reveals that the students acknowledged they did not fully understand the given problem. This difficulty stemmed from a reluctance to carefully read story problems, resulting in inadequate comprehension, despite the problems being contextualised in everyday situations. The student could only formulate simple ideas in response to explicit questions but failed to develop comprehensive mathematical models consistent with these initial ideas. Additionally, S1 admitted to not understanding how to use the *Symbolab* application effectively. This limitation arose from the student's longstanding aversion to mathematics; consequently, the student merely followed the teacher's instructions when introduced to *Symbolab* without seeking to understand its functionality. However, when the teacher provided personalised guidance that linked the story problem to *Symbolab's* features, the student began to grasp that the application was not as complicated as initially perceived.

Furthermore, analysis of student S2 (medium ability level) reveals that the student was able to formulate simple ideas aligned with the problem context and construct a mathematical model. While S2 demonstrated adequate problem comprehension, difficulties emerged during the graphing phase. These errors stemmed from the incorrect use of inequality notation, which resulted in erroneous graphs. When using the *Symbolab* application to graph linear inequality systems, the visual output directly reflected the commands entered. As a result of incorrect inequality symbols, the shading direction was also incorrect. Of the two inequality models created by the student, only one was accurate, resulting in incomplete explanations of the determination of shading direction. Additional obstacles arose during the final computation phase. The student made errors in identifying the intersection point of two lines, incorrectly derived x- and y-values, and failed to address the specific question posed in the problem.

The interview revealed that S2 required considerable time to analyse the given problem. The student had not yet developed the ability to immediately interpret mathematical phrases such as “no more than” and “less than”. This difficulty in translating these expressions into proper inequality forms affected the accuracy of the graphical representations. S2 acknowledge being able to use the *Symbolab* application effectively with previously formulated inequalities. The student found it helpful for creating graphs, determining shading directions, and finding intersection points from the application’s visual output. However, due to the initial error in inequality notation, the resulting graphs were incorrect. When completing the final computations, S2 also admitted to making calculation errors that prevented obtaining the correct answer as requested in the problem.

Analysis of S3’s work demonstrated superior mathematical communication skills compared to S1 and S2. This student successfully translated the problem into mathematical symbols, formulated an appropriate mathematical model consistent with both the symbolic representation and problem requirements, and then utilised the *Symbolab* application to generate graphs. S3 carefully attended to the shading direction to identify the solution region and determine the intersection point between the two lines. On the answer sheet, the student documented the graphing procedure, explained the reasoning derived from inequality signs for determining shading direction, and outlined the steps for finding the intersection point. S3 compared the manually obtained results with those from the *Symbolab* application. After verifying that both methods yielded identical results, the student proceeded to calculate the final answer to determine the maximum and minimum values as specified in the problem. However, during the final computation phase, a multiplication error occurred, resulting in an incorrect answer.

Interviews with S3 revealed that the student develops problem-solving skills through careful, repeated reading. This student first comprehended the problem holistically before addressing the specific questions. S3 acknowledged initial difficulties with mathematical statements for determining greater-than or less-than inequality signs and compensated by creating simpler analogous problems for better understanding. Overall, S3 successfully solved the given story problems with substantial support from the *Symbolab* application, which proved highly beneficial in the problem-solving process. The student reported developing an understanding of *Symbolab’s* functionality, which fostered interest in learning in learning and served as a valuable resource when encountering difficulties. S3 expressed hope that the teacher would incorporate similar learning applications during classroom instruction to enhance engagement and reduce monotony.

Overall, many students continued to experience difficulties solving story problems in linear programming, which contributed to deficiencies in their mathematical communication skills. Students struggled to articulate the ideas in their minds after reading story problems, resulting in difficulties formulating appropriate mathematical models. This finding aligns with Asgafi's [13] explanation that students' difficulties in connecting mathematical ideas to real phenomena and in explaining concepts constitute primary causes of low mathematical communication skills. Lutviana [14] similarly reported that students experience persistent difficulties in converting story problems into mathematical models, such as equations and graphs. Based on these research findings, it can be concluded that many students face substantial challenges in solving story problems, which directly impact their mathematical communication abilities.

Classroom observations reveal that students remained predominantly passive during the learning process. Despite the teacher's effort to create engaging instruction through learning media, teaching students to use the *Symbolab* application, posing questions, and incorporating humour, only a small number of students gradually became active participants. The research findings indicated that 37.5% of students demonstrated low-category mathematical communication skills. This result raises significant concerns for classroom instruction. The researcher also observed that the students rarely received practice problems requiring problem-solving, limiting their training in solution-finding. Teachers typically assigned routine problems that involved direct numerical computation and infrequently utilised learning media that could invigorate the classroom atmosphere. Kusuma & Manoy [15] emphasised that, for students to develop strong communication skills, teachers should provide more practice with story problems that require students to express their ideas both in writing and orally. Oktavia & Lefrida [16] similarly stated that students need additional practice in explaining mathematical concepts in writing, particularly in constructing logical and systematic arguments.

Mathematical communication skills constitute essential competencies in mathematical learning activities, as they are employed throughout the problem-solving process, from interpreting story problems through symbols and visual representations to expressing ideas aligned with the given problem. Mathematical communication skills also encompass the ability to construct solutions systematically and sequentially [17]. Hanipah & Sumartini [18] explained that mathematical communication integrated competence with clear and accurate mathematical ideas. Mathematical communication includes the ability to read, interpret, and explain mathematical problems correctly. The use of appropriate mathematical language enables students to access accurate explanations and develop a clear understanding of problems. Through mathematical communication, students can articulate and explain solution methods [19]. By systematically communicating their chosen approaches, students can receive input from others and revise ineffective solution strategies.

Mathematical communication extends beyond verbal expression of ideas to include the use of various mathematical representations, such as diagrams, graphs, and mathematical formulas [20]. By visualising mathematical concepts, students can express their understanding more clearly, thereby facilitating the problem-solving process. Additionally, mathematical communication provides opportunities to explain the procedures used to solve problems and the results obtained. By presenting discovered solutions, students can assess their correctness and adequacy and implement improvements when necessary. Khadka [21] reported that students who participate more actively in mathematical communication tend to demonstrate deeper understanding and higher classroom engagement.

Developing students' communication skills requires supportive learning media that promote active engagement during the learning process. The integration of technological learning media in application form is expected to facilitate the solving of mathematical problems, particularly story problems [22]. One such mathematical application is *Symbolab*. *Symbolab* is a sophisticated tool designed to support advanced mathematics study. This application enables users to learn, practice, and obtain detailed solution descriptions through scientific symbols and notations. As a scientific calculator, *Symbolab* provides comprehensive support for students to understand content and obtain desired answers, complete with a discussion of relevant questions [10]. The step-by-step solution feature provided by *Symbolab* not only presents answers but also explains the problem-solving process in detail. This feature helps students understand and comprehend the underlying mathematical reasoning involved in solving the problems. The use of innovative learning media, such as Symbolab, enables students to enhance their mathematical abilities and has been shown to improve conceptual understanding [23]. Research by Arwadi & Thalib [24] demonstrated that most students achieved improvements in conceptual understanding and problem-solving through the use of the *Symbolab* application in mathematics learning. Consistent with research by Paulin & Jean Baptiste [25], groups using Symbolab demonstrate significantly higher increases in scores than the learning group without *Symbolab*. The use of *Symbolab* significantly enhances students' understanding and performance. Based on these findings, it can be concluded that the *Symbolab* application is expected to improve students' mathematical communication skills because it employs symbols, visual representations, and clear explanations at each step of the problem-solving process.

4. CONCLUSION

This study aimed to analyse students' mathematical communication skills in solving linear programming word problems using the *Symbolab* application. The findings indicate that 37.5% of students were in the low category, 37.5% in the medium category, and 25% in the high category of mathematical communication skills. Students in the low and medium categories commonly struggled to translate contextual problems into mathematical symbols and models. These difficulties led to errors in graph construction, determining shading regions, and completing final computations. Although the *Symbolab* application helped visualise graphs and check solution steps, it was insufficient to overcome students' difficulties in interpreting problems and constructing appropriate mathematical models. Overall, the result indicates that technological tools can support procedural understanding, but the development of mathematical communication skills requires strong instruction in reading comprehension and mathematical modelling.

This study has several limitations. Participants were limited to students from one school, the learning material focused solely on linear programming, and the study examined the use of a single application, *Symbolab*. Therefore, the findings may not be generalised to different contexts, topics, or technological tools.

Teachers are encouraged to integrate Symbolab into explicit instruction and guided practice for translating story problems into mathematical models. Learning activities should emphasise students' ability to express ideas through symbols, models, graphs, and written explanations, rather than focus solely on final answers. Future studies may design instructional interventions that combine *Symbolab* with explicit instruction in reading and modelling word problems and examine their impact on students' mathematical communication skills across different schools and grade levels.

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