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STUDENTS' MATHEMATICAL LITERACY ABILITY IN SOLVING HIGH ORDER THINKING SKILLS PROBLEMS OF CLASS XI LINEAR PROGRAM

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ABSTRACT

The development of mathematical literacy is a critical aspect of mathematics education in Indonesia. Beyond computational proficiency, students must be equipped to apply mathematical concepts in real-life problem-solving scenarios. This study focuses on analyzing the mathematical literacy skills of grade XI students at SMA Negeri 2 Blora in solving Higher Order Thinking Skills (HOTS) problems related to linear programming. Employing a descriptive qualitative method, the research involved three participants representing high, medium, and low literacy proficiency levels. Data collection was conducted through written assessments and interviews, and data validation was ensured using triangulation techniques. Data analysis followed steps of collection, reduction, presentation, and conclusion drawing. The findings reveal that students with high literacy proficiency demonstrated competency across all mathematical literacy indicators, including communication, the use of language and operations, symbols, formal and technical aspects, mathematization, representation, problem-solving strategies, and reasoning. Meanwhile, students with moderate proficiency fulfilled only some indicators, specifically communication and the application of language and operations. In contrast, students with low proficiency exhibited mastery solely in communication.

Keywords: HOTS, Linear Program, Mathematical Literacy

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PRELIMINARY

Mathematical literacy is a pivotal component of mathematics education, aligning with the educational objectives in Indonesia. Comparable to reading and writing, mathematical literacy forms a fundamental skill that students must master. Proficient mathematical literacy not only enhances problem-solving abilities but also fosters a generation capable of making informed decisions and actively participating in societal development (Imamuddin, 2022). It equips individuals to appreciate the practical applications and significance of mathematics in daily life (OECD, 2023). In addition, mathematical literacy emphasizes students' ability to analyze, reason, and convey thoughts effectively in dealing with solving mathematical problems they experience.

Recognizing its importance, the Ministry of Education and Culture has undertaken initiatives to improve learning quality and students' competency. One strategy involves incorporating Higher Order Thinking Skills (HOTS) into the curriculum, given its close relationship with mathematical literacy (Simamora & Tilaar, 2021). As mathematical literacy involves the ability to formulate, utilize, and interpret mathematics for problem-solving, it aligns with HOTS, which focuses on students' capacity to transfer knowledge into real-world contexts (Astuti. 2018). This connection is further emphasized by the 21st-century competencies, which include character development, 4C skills (critical thinking, creativity, collaboration, and communication), and literacy proficiency.

HOTS-based problems are essential for honing students' mathematical literacy in alignment with 21st-century skills (Widana, 2017). However, despite the implementation of HOTS-oriented curriculum standards since 2013, Indonesian students' mathematical performance lags behind that of neighboring countries. For example, the Program for International Student Assessment (PISA) ranks Indonesia 6th among seven ASEAN nations, with an average mathematics score of 366 compared to the international average of 472 (OECD, 2022). This indicates students' limited readiness to tackle HOTS-oriented problems effectively, a deficiency attributed to low levels of mathematical literacy.

Linear programming is a HOTS-related topic that presents challenges for students due to its contextual and complex nature. Effective problem-solving in this area requires converting real-world problems into mathematical models, which often proves difficult for students (Rahmawati & Permata, 2018). These challenges stem from the higher analytical and modeling skills demanded by HOTS problems, which involve connecting concepts and devising problem-solving strategies (Fanani, 2018). Linear programming problems typically involve linear inequalities and optimization functions (Irfan, 2020) and are widely applicable in maximizing outcomes or minimizing costs across various fields (Murota, 2021).

Students’ difficulties with linear programming often result from gaps in fundamental mathematical concepts and their inability to translate contextual problems into mathematical models (Ridwan et al., 2019; Utami et al., 2022). Consequently, students must develop a solid conceptual foundation and practice extensively to improve their proficiency in linear programming. A deeper understanding of prerequisite materials will enable students to address these challenges effectively, thereby enhancing their mathematical literacy. However, there is no research that explores the analysis of mathematical literacy in relation to linear program material, especially when students handle higher order thinking skills.

Based on the description above which shows the low mathematical literacy skills of students and looking at the results of the PISA survey which shows that Indonesia's literacy score is still far behind other countries, the researchers are interested in examining the mathematical literacy skills of grade XI students entitled: “Mathematical Literacy Skills of Students in Solving High Order Thinking Skills Linear Program Class XI Problems”.

METHODS

This study employed a qualitative descriptive methodology aimed at exploring and understanding specific social phenomena or processes (Creswell & Creswell, 2018). A case study design was adopted to facilitate an in-depth examination of individuals, groups, or events within a bounded context (Sutama, 2019). The research was conducted in class XI SMA Negeri 2 Blora with a total of 33 students and the sample used amounted to three people, including one student with a high level of mathematical literacy, one student with moderate literacy, and one student with low literacy. Samples were taken based on the results of student work assessments that had been categorized by the level of students' mathematical literacy skills, as presented in Table 1.

Table 1. Category of Students' Mathematical Literacy Level

No	Category	Score Criteria
1.	High	$X \geq (\bar{X}+SB)$
2.	Moderate	$(\bar{X} - SB) \leq X < (\bar{X} + SB)$
3.	Low	$X \leq (\bar{X} - SB)$

Source: Nurlaili et al., (2022)

The data collection process utilized written tests and semi-structured interviews. The test aimed to measure students' mathematical literacy through two descriptive HOTS problems focused on linear programming. These problems were designed to evaluate students' proficiency across six key indicators of mathematical literacy: 1) communication, 2) application of language and operations, symbols, formal and technical, 3) mathematization, 4) representation, 5) problem-solving strategies, and 6) reasoning and argumentation (PISA, 2019). The interviews served to elucidate students’ thought processes during problem-solving and to validate their written responses.

The research instruments underwent a rigorous validation process involving two validators: one a mathematics education lecturer from Universitas Muhammadiyah Surakarta and the other a mathematics teacher from SMA Negeri 2 Blora. To ensure data reliability, triangulation techniques were employed. Triangulation involved cross-verifying data from multiple sources, namely test results and interview findings, to enhance validity and reduce bias (Moleong, 2011; Sugiyono, 2015).

Data analysis followed the framework proposed by Miles (1992), comprising four systematic steps: 1) data collection, 2) data reduction, 3) data presentation, and 4) conclusion drawing and verification. These stages ensured a comprehensive interpretation of the data, enabling the identification of patterns, themes, and insights relevant to the research objectives.

RESULT AND DISCUSSION

The findings of this study provide insights into students' mathematical literacy skills in solving HOTS-based linear programming problems. The analysis categorized the results according to three levels of mathematical literacy: high (subject ST), moderate (subject SS), and low (subject SR), as presented in Table 2.

Table 2. Test results of mathematical literacy skills

No	Mathematical Literacy Ability	Subject ST		Subject SS		Subject SR	
		Question					
		1	2	1	2	1	2
1.	Communication	✓	✓	✓	✓	✓	✓
2.	Use of Language and Operations, Symbols, Formal and Technical	✓	✓	✓	✓	✓	–
3.	Mathematization	✓	✓	✓	✓	✓	–
4.	Representation	✓	✓	–	–	–	–
5.	Problem-Solving Strategies	✓	✓	✓	–	–	–
6.	Reasoning and Argumentation	✓	✓	–	–	–	–

Information:
✓ : Meet the indicators
- : Does not meet the indicators

The findings from the analysis of each subject's mathematical literacy skills are detailed as follows.

1. **Work Result of Problem Number 1**

   In addressing the first problem, all three subjects (ST, SS, and SR) effectively identified and articulated the provided information, including the known variables and the objectives of the problem. They demonstrated proficiency in representing the variables symbolically ("x" and "y") and successfully converted the contextual problem into accurate mathematical models. The following is the work of subject SS in the first problem:

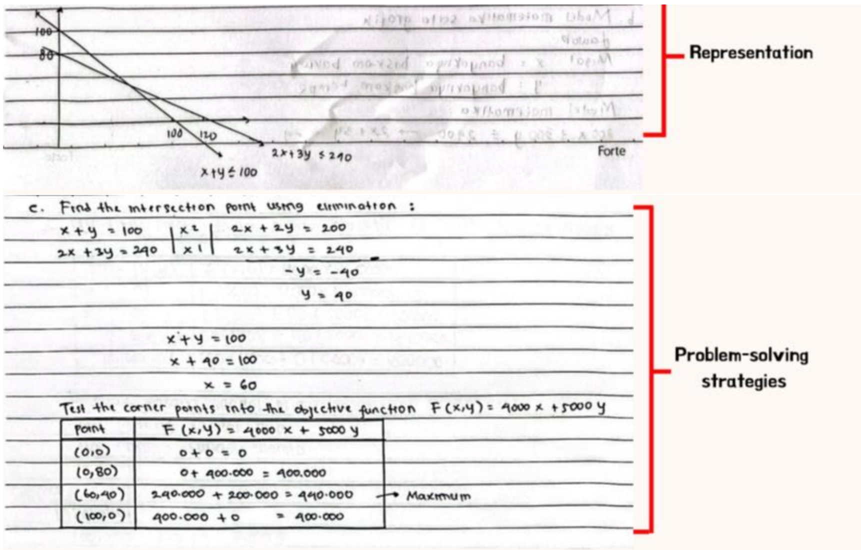

Figure 1. The result of SS subject's work on the first question

An analysis of the work produced by Subject SS reveals inaccuracies in graph representation, particularly the omission of shading the Feasible Region (DHP), indicating that the representation indicator was not met. Nevertheless, Subject SS demonstrated the ability to outline problem-solving steps and identify strategies by determining the intersection points of "x" and "y" through elimination and substitution methods. This process included testing the coordinates (x, y) in the objective function. Insights from the interviews further confirm that Subject SS employed elimination to identify the intersection points before substituting them into the objective function. However, the subject failed to provide a concluding statement in their solution. Consequently, of the six indicators of mathematical literacy, Subject SS fulfilled only four: communication, the use of language and operations, symbols, formal and technical aspects, mathematization, and designing problem-solving strategies.

The following is the result of SR subject's work on mathematical literacy test question number 1 can be seen in figure1.

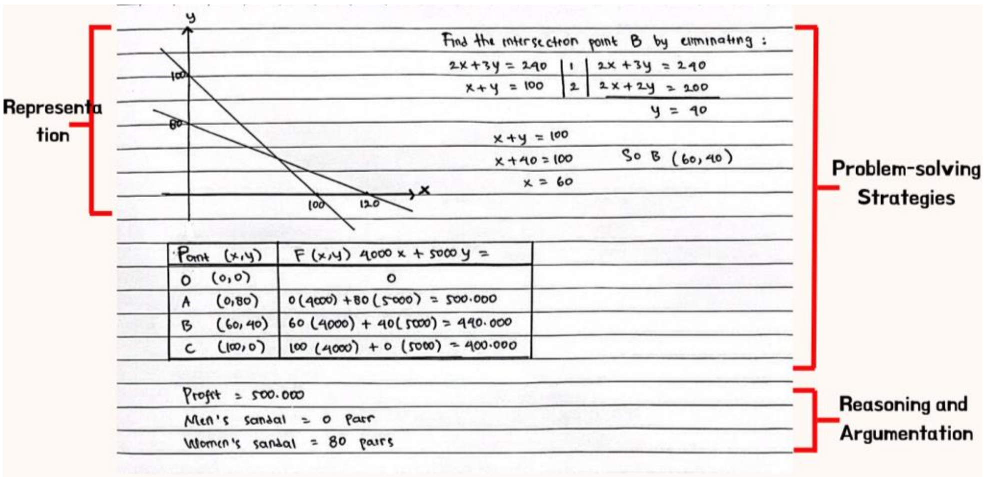

Figure 2. The results of SR subject's work on the first question

Analysis of Subject SR's work reveals that the subject was unable to correctly construct the graph, thereby failing to meet the representation indicator. As shown in Figure 2, Subject SR only drew the equation line without shading or indicating the Feasible Region (DHP). Regarding problem-solving strategies, the subject was only able to identify the intersection points of the x-axis and y-axis and draw the corresponding line, as depicted in Figure 2. Additionally, there was a calculation error when substituting point A (0.80) into the objective function. Consequently, Subject SR did not fulfill the problem-solving strategy indicator, which impacted the final solution and led to an incomplete reasoning and argumentation process. The errors in the final result prevented the subject from meeting the reasoning and argumentation indicator.

In the interview, Subject SR did not fulfill the representation indicator, because he was unable to present the graph correctly. Subject SR also felt less careful in the calculation process so that there were wrong final results and affected the final conclusion which was also wrong.

2. **Result of Problem Number 2**

Subject ST was able to correctly solve Problem 2, meeting all six mathematical literacy indicators. This included the ability to identify and articulate the given and sought information, represent the variables using symbols ("x" and "y"), translate the context into mathematical language or modeling, accurately represent graphs, design problem-solving strategies, and draw valid conclusions. In contrast, Subjects SS and SR were unable to solve Problem 2 correctly. While both subjects could explain the information in the problem, neither fulfilled the representation indicator, designed problem-solving strategies, nor provided a final conclusion. The key difference between them lies in Subject SS's ability to fulfill additional mathematical literacy indicators, including the use of language and operations, symbols, and formal and technical aspects, as well as modeling mathematics. On the other hand, Subject SR only met the communication indicator.

The outcomes of Subject SS's performance on the mathematical literacy assessment are presented below.

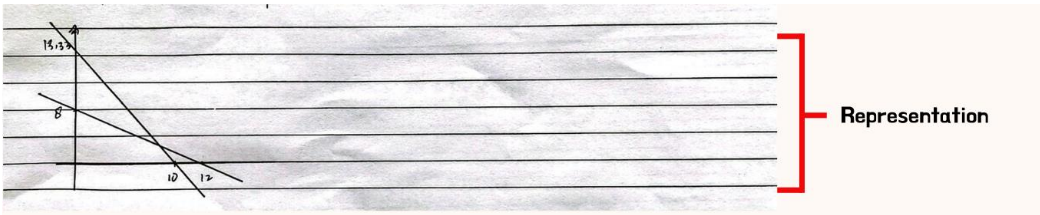

Figure 3. The Result of SS Subject's Work on the Second Problem

According to the analysis, Subject SS has not demonstrated proficiency in representation, as the graph was not drawn correctly. The mistake made by Subject SS is evident in Figure 3, where the Feasible Region (DHP) was not shaded. Additionally, Subject SS struggled with designing problem-solving strategies and reasoning, as the problem was not fully solved. This was further confirmed during the interview, where Subject SS expressed confusion and was unable to complete the task.

The results of SR subject's work on the math literacy test questions can be seen in Figure 4.

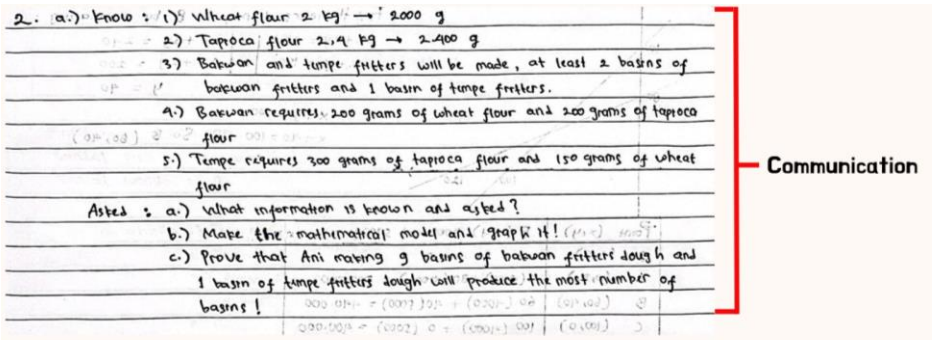

Figure 4. Result of SR Subject's Work on the Second Problem

Based on Figure 4, subject SR has not mastered all indicators of mathematical literacy in problem number 2. Subject SR is only able to master communication skills, as evidenced by being able to write down information from the problems given. This is also reinforced from the results of the interview, subject SR had difficulty in working.

Based on the analysis, Subject ST demonstrated mastery of all mathematical literacy indicators. This finding aligns with previous studies (Kurniawan & Khotimah, 2022), which indicate that students with high mathematical literacy can present information clearly, represent variables correctly, translate problems into mathematical models, devise appropriate problem-solving strategies, use mathematical operations correctly, and draw accurate conclusions. Research by (Ratri & Setyaningsih, 2020) also supports this, suggesting that high-ability students meet all the key mathematical literacy indicators, such as communication, mathematization, representation, reasoning, problem-solving strategies, and proper use of symbols. Further, studies (Lutfiyana et al., 2022) highlight that students with high literacy skills successfully solve problems and meet all mathematical literacy indicators. (Agustina & Khotimah, 2024) similarly found that students with visual learning styles demonstrate high mathematical literacy, as evidenced by their ability to meet all the literacy indicators. Additionally, (Ramini & Setyadi, 2021) noted that high AQ students (climbers) are capable of understanding the problem, developing plans, and articulating solution steps clearly and coherently.

Subjects with moderate mathematical literacy skills made errors in solving both Problem 1 and Problem 2. In Problem 1, the error stemmed from an incorrect graph representation, where the Feasible Region (DHP) was not shaded. Additionally, in the reasoning and argumentation phase, the subject failed to provide a final conclusion. As a result, Subject SS was only able to meet the indicators of communication, use of language and operations, symbols, formal and technical aspects, mathematization, and problem-solving strategy design. This is consistent with the findings of (Ratri & Setyaningsih, 2020), who suggested that students with moderate abilities can identify and define known and unknown variables and apply steps in problem-solving but struggle to draw conclusions. In Problem 2, Subject SS was able to identify the given information, present the variables for modeling, and translate the context into mathematical language. These results are consistent with the research of (Qadry et al., 2022), who noted that students with moderate mathematical literacy can convert problems into mathematical models using symbols. (Muzaki & Masjudin, 2019) also found that students with moderate abilities can clearly and thoroughly identify known and unknown elements and create mathematical models. However, in Problem 2, Subject SS failed to fulfill the indicators for representation, problem-solving strategies, and reasoning and argumentation. (Lestari &

Effendi, 2022) argued that students in the moderate category struggle with problem-solving, fail to evaluate their solutions, and often omit conclusions from their work. These results align with the findings of (Ayu et al., 2023), which indicate that students with moderate levels of mathematical literacy often encounter errors in problem-solving due to inaccuracies in the application of problem-solving strategies.

Subject SR, who exhibited difficulties in answering the problems, was only able to master the communication indicator, namely identifying the problem. This finding aligns with research by (Murtiyasa & Perwita, 2020), who observed that students with low abilities possess only communication skills and are unable to solve problems effectively. Furthermore, low-achieving students often struggle to formulate mathematical equations due to a lack of mastery of the underlying concepts (Gustina & Khotimah, 2018). (Khoirudin et al., 2017) similarly found that students with low mathematical ability struggle to solve problems correctly and often cannot make assumptions or draw conclusions. The subject's inability to relate the problem to mathematical content and interpret conclusions correctly is consistent with findings by (Nurinayah & Nur, 2023). Research by (Andari & Setianingsih, 2021) also emphasized that students with low abilities struggle with understanding problem-solving steps, designing and applying strategies, and drawing conclusions. These students have not mastered the indicators of mathematization, problem-solving strategies, or reasoning and argumentation. According to (Nurhaliza Ali & Ni, 2023), students with low numeracy skills can identify the known and unknown information in a problem but struggle to solve it due to a lack of understanding of the problem (Windasari & Setyaningsih, 2024). In the low category, students can only achieve the formulation of mathematical processes-essentially, they are only able to write down the known and unknown elements and convert the problem into mathematical language (Farida et al., 2021).

CONCLUSION

The findings indicate that students with high mathematical proficiency successfully achieved all six indicators of mathematical literacy. These include communication, application of language and operations, use of symbols, formal and technical aspects, mathematization, representation, designing problem-solving strategies, and reasoning and argumentation. Students with moderate mathematical proficiency demonstrated competency in several indicators, specifically communication, application of language and operations, use of symbols, formal and technical aspects, and mathematization. However, students with lower mathematical proficiency were limited to meeting only one indicator, namely communication. It is hoped that future research can be conducted to develop students' mathematical literacy through learning models. Thus, using learning models is expected to help students improve their mathematical literacy even better.

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