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STUDENTS MATHEMATICAL LITERACY VIEWED FROM CURIOSITY IN PROBLEM BASED LEARNING

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Abstract

Mathematical literacy may be described as the capacity of an individual to comprehend, mobilize, and communicate mathematical reasoning across diverse life situations in order to resolve problems meaningfully. One instructional approach frequently associated with strengthening this competence is Problem-Based Learning (PBL), which situates students within authentic problem scenarios and compels active reasoning engagement rather than passive reception. The present inquiry intends to explore and portray students' mathematical literacy achievement through E-Module-supported PBL, interpreted through the stratification of students' curiosity levels. The research method used is qualitative descriptive. This study analyzes and describes students' mathematical literacy abilities based on categories of student curiosity. The research subjects involved 10th-grade PM 2 students at SMKN 1 Kendal for the 2024/2025 academic year. Empirical findings indicate that learners categorized with elevated curiosity demonstrate mastery across all mathematical literacy indicators, whereas those within moderate and low curiosity tiers exhibit constraints particularly during interpretation and evaluative stages of solution processes. These results accentuate the salience of affective disposition especially curiosity in maximizing mathematical literacy within problem-based environments.

Keywords: Curiosity, Mathematical Literacy, Problem Based Learning

Abstrak

Literasi matematis merupakan kemampuan individu dalam memahami dan menggunakan matematika pada berbagai konteks untuk memecahkan masalah, serta mengomunikasikan solusinya secara efektif. Salah satu model pembelajaran yang relevan untuk memperkuat kompetensi ini adalah Problem-Based Learning (PBL), yang mendorong eksplorasi dan penalaran matematis secara aktif. Penelitian ini bertujuan untuk menganalisis dan mendeskripsikan literasi matematis siswa melalui pembelajaran PBL berbantuan E-Modul ditinjau dari tingkat curiosity siswa. Metode penelitian yang digunakan adalah deskriptif kualitatif. Penelitian ini menganalisis serta mendeksripsikan kemampuan literasi matematis siswa berdasarkan kategori curiosity siswa. Subjek penelitian melibatkan siswa kelas X PM 2 SMKN 1 Kendal tahun pelajaran 2024/2025. Hasil penelitian mendeskripsikan bahwa siswa dengan tingkat curiosity tinggi mampu menguasai seluruh indikator literasi matematis, sedangkan siswa dengan tingkat curiosity sedang dan rendah cenderung kesulitan pada tahap menafsirkan dan mengevaluasi solusi atau hasil dari pemecahan masalah. Hal ini menggarisbawahi pentingnya aspek afektif, khususnya curiosity, dalam peningkatan literasi matematis siswa melalui pembelajaran berbasis masalah.

***Kata kunci**: Curiosity, Literasi Matematis, Problem Based Learning.*

INTRODUCTION

Mathematics is defined as a body of abstract knowledge and ideas developed through a series of methods to reach logical conclusions (Thanheiser, 2023). It serves as a fundamental tool for cultivating effective thinking processes (Yuniarti, 2014) and is indispensable for solving problems encountered in daily life (Kistian & Verawati, 2020; Nguyen & Frigg, 2021), as it encompasses concepts designed to shape

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logical and realistic mindsets (Latif & Akib, 2016). Contemporary mathematics instruction in the twenty-first century context demands reinforcement of literacy competence, character formation, and Higher Order Thinking Skills (HOTS) (Haerudin, 2018; Radmehr & Vos, 2020). Mathematical literacy occupies central importance because it encompasses the ability to formulate, apply, and interpret mathematical constructs within varied contextual settings to support reflective and constructive decision-making processes (OECD, 2018; Stacey & Turner, 2015). Furthermore, it enhances the quality of students' mathematical reasoning (Brewley, 2012). Mathematical literacy significantly influences reading and listening comprehension (Holenstein, Bruckmaier, 2021), empowers individuals to analyze situations and draw sound conclusions (Genc & Erbas, 2019), and enables a critical engagement with everyday circumstances (Steen, 2022).

However, current field realities indicate a significant gap between curriculum expectations and student achievement. PISA 2022 data reveals that only 18% of students in Indonesia achieve at least Level 2 proficiency in mathematics, while no students have reached Levels 5 and 6 (OECD, 2023). A similar condition was observed at SMK Negeri 1 Kendal, where observations and interviews showed that students encounter difficulties in solving contextual word problems. This issue is closely linked to the continued use of conventional learning models that are not yet fully student-centered. Consequently, students tend to be passive and dependent on teacher explanations, despite possessing a high potential for curiosity.

One of learning model can enhancing mathematical literacy is Problem-Based Learning (PBL) (OECD, 2023). PBL operates as a learner-centered pedagogical structure wherein complex and authentic problems constitute the principal driver of learning progression, contrasting with traditional dissemination of formulas and procedural exposition (Joshi, Desai, & Tewari, 2020). Through engagement with ill-structured tasks, students cultivate adaptable conceptual under-standing, strategic problem-solving proficiency, autonomous learning orientation, collaborative interaction, and intrinsic motivational patterns (Yew & Goh, 2016). Empirical evidence further demonstrates that PBL enhances mathematical critical thinking and academic performance (Nafiah & Suyanto, 2014), while simultaneously fostering creativity in conceptual discovery and daily-life problem resolution (Kenedi & Helsa, 2017). Through real-world issues, students can become more motivated and effectively engaged in accurately defining or analyzing problems, finding solutions (Gorghiu et al., 2015), evaluating options, and drawing conclusions (Sinambela, 2013).

Previous research has offered various solutions to improve mathematical literacy. A body of prior investigations consistently corroborates the effectiveness of PBL in stimulating analytical reasoning and learning achievement through engagement with authentic, non-routine problem contexts (Nafiah & Suyanto, 2014). Furthermore, the use of digital media, such as E-Modules within a PBL framework, is known to support learning independence and more dynamic problem-solving (Jaenudin, Baedhowi, & Murwaningsih, 2017). Although PBL and E-Modules have been widely discussed, the integration of vocational

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students' curiosity as an internal motivation for seeking information without compulsion within an E-Module-based PBL model remains rarely explored in depth.

This research endeavors to address an identified gap by incorporating the variable of student curiosity into an E-Module-facilitated PBL framework. The initiative seeks to harmonize inherent student inquisitiveness at SMKN 1 Kendal with digital instructional media to elevate mathematical literacy outcomes. The integration aspires not solely to improve literacy proficiency but also to nurture learner autonomy and sustained engagement. Empirically, the study examines the effect of implementing E-Module-based PBL on literacy enhancement when interpreted through varying curiosity intensities. Theoreti-cally, it aims to expand scholarly discourse concerning the intersection of educational psychology and digital pedagogy within vocational schooling. Practically, the results are anticipated to inform educators in designing mathe-matics instruction that is both intellectually demanding and responsive to the technological orientation of contemporary vocational learners.

METHODS

This study was designed using a qualitative descriptive research method. The study was conducted in Class X PM 2 at Kendal State Vocational High School 1, which has 36 students. Research subjects were selected using purposive random sampling, taking into account the students' curiosity levels. Based on the results of the curiosity questionnaire distributed, three groups were identified: subjects with low, moderate, and high curiosity. From this sampling technique, three students were selected as research subjects: one student each with low, moderate, and high curiosity. The subjects were administered a test to measure their mathematical literacy. Subsequently, each selected student was interviewed regarding their mathematical literacy based on the completed answer sheets. In this study, the instruments used consisted of a curiosity questionnaire, a mathematical literacy test, and interview guidelines. The curiosity questionnaire was used to determine the students' level of curiosity. The test was used to assess students' mathematical literacy skills in the PBL model supported by e-modules. The interview was used to confirm the students' work results.

To gather information on how well students can demonstrate mathematical literacy based on their level of curiosity, the researchers prepared three instruments: a curiosity questionnaire, a mathematical literacy test, and interviews. To determine the level of curiosity, students were given a curiosity questionnaire distributed during class.

In this study, the researcher developed curiosity indicators, which are an evolution and synthesis of frameworks from the Ministry of National Education (Markey & Loewenstein, 2014; OECD, 2018; Raharja, Wibhawa, & Lukas, 2018), as shown in Table 2.

Table 2. Indicators of Students Curiosity.

No	Name	Top column name
1	Students' desire to understand deeply about the material learnt	Paying attention to the teacher's explanation in class Listening to a friend's explanation in class

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No	Name	Top column name
2	Ask or read sources outside the textbook about material related to the lesson	Ask friends or teachers about the material being discussed and not understood
		Looking for books or teaching materials other than those used by the teacher in class about the material being discussed
		Ask the teacher or friends about something related to the subject matter being discussed but not/not yet discussed by the teacher in class
3	Have enthusiasm to find answers	Take the initiative to find answers to the questions given
		Enjoys finding and solving answers to given problems
4	Explore the tasks and materials	Working on problems given by the teacher and finding out the solution by yourself
		Working on problems in books or modules even though the teacher has not instructed them to do so
5	Diligent in searching for information on assignments and materials provided	Seek information when faced with a problem

Students' mathematical literacy was assessed using mathematical literacy indicators, and the results were reported in the form of a written test known as the mathematical literacy test. The mathematical literacy test was administered to all students in 10th-grade PM 2. The mathematical literacy indicators in this study, based on mathematical processes combined with the OECD (2018) core mathematical competencies, are presented in Table 1.

Table 1. Indicators of Mathematical Literacy

Mathematical Process	Indikator
Formulating situations mathematically	• Formulate problems as mathematical statements. • Identify problems and develop a plan for solving them.
Using mathematical concepts, facts, procedures, and reasoning	• Use mathematical concepts, facts, and procedures to solve problems.
Interpreting, applying, and evaluating mathematical results	• Interpret solutions to solve problems. • Evaluate solutions or the results of problem-solving.

To validate the results indicating a relationship between curiosity and students' mathematical literacy, the researcher and the research subjects conducted individual interviews. From the thirty-six research subjects, three research samples were selected using purposive sampling. The focus of this study was on selecting samples based on high, moderate, and low curiosity criteria. The subject with low curiosity was designated S1, the subject with moderate curiosity was designated S2, and the subject with high curiosity was designated S3.

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Data analysis in this study employed descriptive analysis techniques through three stages: data reduction, data presentation, and drawing conclusions (Sukestiyarno, 2020). In detail, the data analysis process involved reducing the data by analyzing students' responses, supported by data from in-depth interviews, to clarify the stages students went through in answering the questions. This was followed by presenting the data in the form of a narrative text and conclusions; the final step was drawing overall conclusions from the data obtained through the data reduction and presentation stages.

The next stage involved drawing conclusions by testing hypotheses. Triangulation in this study was conducted to validate the data from the mathematical literacy tests, curiosity questionnaires, in-depth interviews, observations, and documentation that had been collected. The data reduction stage in this study was carried out to eliminate unnecessary data gathered during the research.

RESULTS AND DISCUSSION

Curiosity questionnaire out-comes were subsequently stratified to categorize participants into distinct curiosity levels for analytical diffe-rentiation. The classification resulting from the subjects' curiosity included high, moderate, and low levels. These classifi-cations were obtained based on the questionnaire results administered to the subjects. The calculation results for the curiosity questionnaire classifi-cations are presented in Table 2.

Table 2 Curiosity Questionnaire Results

Calculation	Category	Amount of Subject
$18 \leq x < 49$	Low	3
$49 \leq x < 64$	Medium	29
$64 \leq x \leq 72$	High	4

Subject determination rely upon categorized curiosity outcomes. Following categorization, selected students undertook literacy testing and participated in in-depth interview concerning their solution process. From analytical examination of Table 2, three representative participants were chosen: one from low, one from moderate, and one from high curiosity cluster. These were coded S1 (low), S2 (moderate), and S3 (high). Researcher then elaborate literacy profile of each subject. Mathematical literacy operationalized into five dimensions: (1) formulation of contextual problem into mathematical expression, (2) identification and planning of resolution strategy, (3) application of mathematical concepts, procedures, and facts, (4) interpretation of derived solution, and (5) evaluation of outcome validity. Integration of written test artifacts with interview transcript enable comprehensive depiction of literacy manifestation according curiosity gradient.

Mathematical literacy in subjects with low curiosity.

Assessment of literacy for low-curiosity participant concentrated on subject S1. Documentation of S1 response for problem number one presented in Figure 1, serving as primary analytical evidence.

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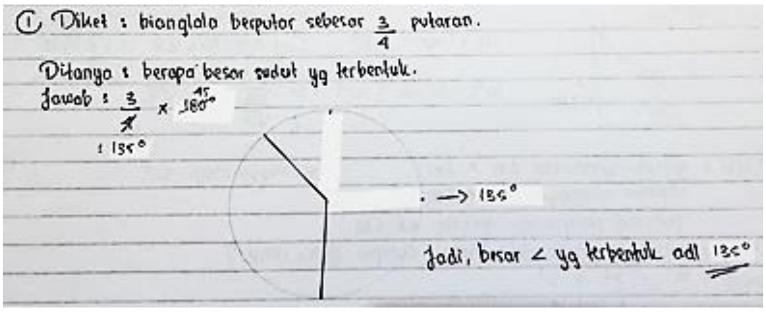

Figure 1. The results of S1's work number 1

At the stage of formulating problems in the form of mathematical sentences, S1 was able to write some of the information contained in problem number 1. S1 wrote what was known and asked quite well but in the questioned part, S1 did not write that what the question asked was to convert into radian units. At the stage of identifying problems and making a solution plan, S1 has correctly written that the angle formed is $\frac{3}{4}$ round. However, at the stage of using the concept, the subject S1 answered by multiplying $\frac{3}{4} \times 180^0$ so as to get the wrong result. After that, the subject also did not convert into units of radians and only answered in units of degrees.

The interview stage was conducted to confirm the results of S1's work on the magnitude of the angle at 1 full rotation and hesitantly answered 3600. The discussion then continued about the reasons why he felt difficult when working on the problem. S1 answered that he did not really understand the concept that the question wanted. Analysis then continued on S1's answer to question number 2 are shown in Figure 2.

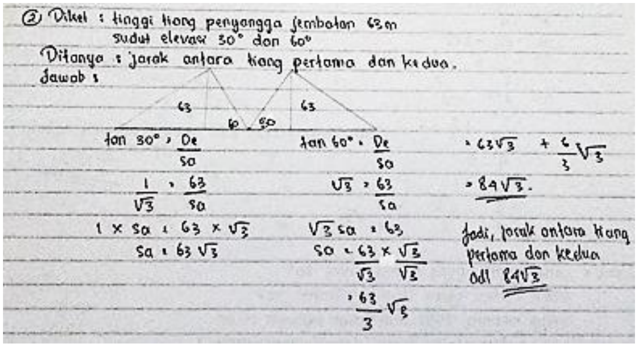

Figure 2. The results of S1's work number 2

For problem number 2, S1 wrote incomplete information, namely not writing the position of the observer so that it formed an elevation angle of 30^0 and 60^0. S1 is less careful in formulating problems into mathematical sentences. At the stage of making a solution plan, S1 is good enough by drawing illustrations, but lacks in distinguishing between the observer angles 30^0 and 60^0 so that the image becomes disproportionate.

From the results of the interview, the data obtained that S1 was unable to understand the problem well and missed an information in the problem so S1 did not write it on his answer sheet. The results of S1's answers to problem

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number 2 also appear incomplete, especially in illustrating the problems of the given problem. S1 has not shown the ability to use the trigonometric concepts learned because he does not understand the problems given and is reluctant to ask the teacher or his friends.

Mathematical literacy in subjects with medium curiosity.

Mathematical literacy of students with medium curiosity was studied from students with the initials S2. The results of S2's work number 1 and number 2 are described in Figures 3 and 4.

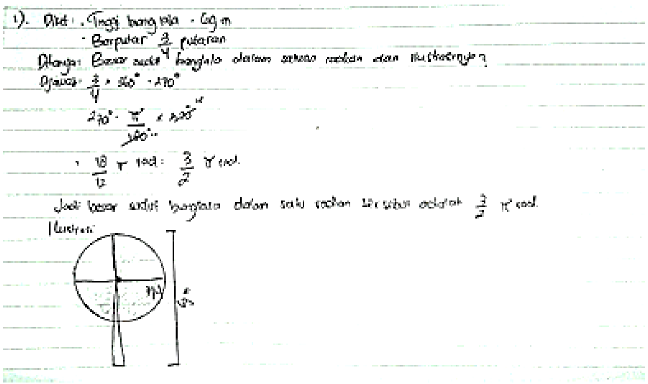

Figure 3. The results of S2's work number 1

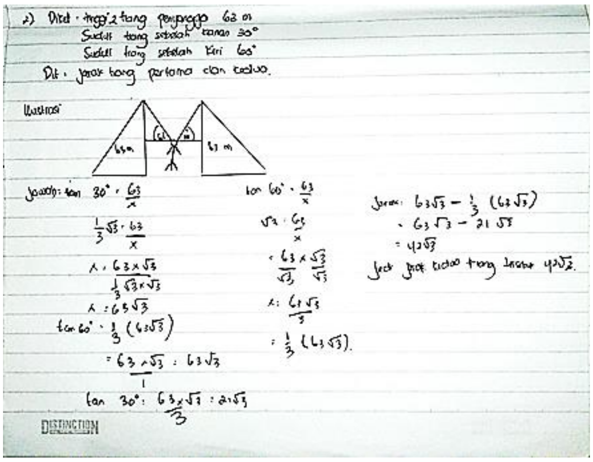

Figure 4. The results of S2's work number 2

S2 can write most of the information contained in questions number 1 and 2 quite well. At the stage of formulating problems in the form of mathematical sentences. S2 wrote well and quite complete about what was known and asked from the problem given and made in mathematical form in problem number 1. For problem number 2, S2 wrote information that was quite complete and could be understood easily.

At the stage of identifying the problem and making a solution plan, S2 wrote quite well by writing that the angle of 1 full circle is 3600 and then converted it into radian units well. The work also showed that S2 was able to interpret the solution to solve the problem quite well in problem number 1.

In question number 2, S2 was able to draw an illustration of a person standing between two bridges and forming an angle of elevation 30^0 and

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60^0 . S2 drew an illustration of a person standing between two bridges and forming an angle of elevation 30^0 and 60^0 less perfectly. At the stage of using trigonometric concepts, S2 worked on problem number 2 quite well. S2 was able to use the concept of trigonometric comparison well as seen in his work. However, the shortcoming of S2 is when the stage of evaluating the solution of the problem given. S2 misinterpreted the distance between two poles on the bridge by calculating the difference in distance between the object and the bridge.

From the interview results, it was found that S2 did not really understand the concept of trigonometry, but S2 discussed with his friends during learning and occasionally asked the teacher if there were things that were not understood. S2 has a desire to know something that is not understood. When confirmed about the results of his work, S2 admitted that he was not careful in working and was in a hurry so he misinterpreted the meaning of the problem. After being interviewed, S2 understood his mistakes and could improve his work.

Mathematical literacy in subjects with high curiosity.

Mathematical literacy of students with high curiosity was assessed from students with initials S3. The results of S3's work number 1 and number 2 are described in Figures 5 and 6.

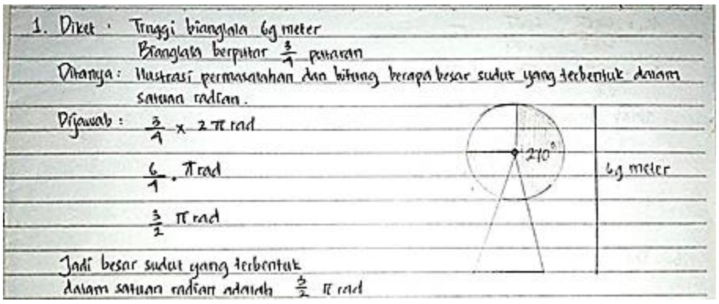

Figure 5. The results of S3’s work number 1

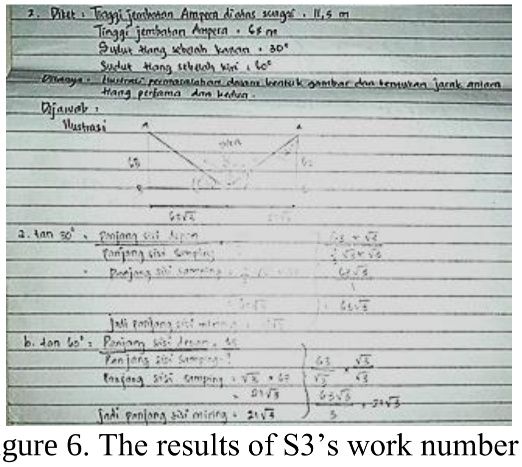
Figure 6. The results of S3’s work number 2

S3 wrote most of the information contained in questions number 1 and 2 well. At the stage of formulating problems in the form of mathematical sentences, S3 wrote what was known and asked of the problem given well in problem number 1. For problem number 2, S3 wrote information that was quite complete and easy to understand.

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At the stage of identifying the problem and making a solution plan, S3 wrote quite well by writing that the angle of 1 full circle is equivalent to 2π radians so S3 immediately multiplied $\frac{3}{4}$ round with 2π radians. This indicates a good concept understanding ability of S3. For question number 2, S3 was able to plan problem solving quite well through the illustration of a pretty good picture although there were a few mistakes, namely the placement of the elevation angle 30^0.

At the stage of using trigonometric concepts, S3 worked on problem number 2 quite well. S3 is able to solve problems in problem number 2 using trigonometric concepts. At the stage of evaluating the solution to the problem given. S3 quite well by adding up the results between the distance to the right and left of the object.

From the results of the interview obtained the results that S3 was able to evaluate the problem given indicated by S3 being able to explain the meaning of the results of the answer even though it was not smooth. S3 also said that if there was something that was not understood, S3 chose to ask or look for the answer in the notebook. S3 admits that there are some things that are not understood but will become clearer if given additional reinforcement by the teacher.

The results of the mathematical literacy assessment for students in the low curiosity group, represented by S1, indicate that out of the five mathematical literacy indicators, students in the low curiosity group achieved only a fairly good level of proficiency on one indicator, while the other four indicators showed less than satisfactory performance. The details of the mathematical literacy achievements of students in the low curiosity group are as follows: the ability to formulate problems in the form of mathematical sentences is fairly good; the ability to identify problems and create a solution plan is poor; the ability to use mathematical concepts, facts, and procedures to solve problems is poor; the ability to interpret solutions to solve problems is poor; and the ability to evaluate solutions or the results of problem-solving is poor. Student S1 had difficulty identifying the problem and determining the solution to the given problem. Operationally, S1 also lacked mastery of basic mathematical operations such as multiplication and division of exponential numbers, particularly numbers in radical form. Based on the interview results, S1 stated that they lacked confidence during lessons, making them afraid to ask questions when there was material they did not understand. S1 also felt embarrassed to ask questions of their groupmates. When asked about the e-module provided, S1 said that they found it difficult to independently understand the prerequisite material, namely the Pythagorean Theorem. These results are consistent with S1's work, which revealed weaknesses ranging from basic concepts to even the simple formulation of mathematical sentences. This is what caused S1 to struggle during the mathematical literacy test. These findings align with those of Puspitasari, Mariyam, and Husna (2024) who noted that students with low curiosity exhibit low literacy skills.

An assessment of the mathematical literacy of students in the moderate curiosity group, represented by S2, indicates that these students achieved only good and fairly good performance on three indicators, while the other two indicators showed less favorable results. S2 demonstrated good ability in

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formulating problems as mathematical statements, as well as fairly good ability in identifying problems and developing solution plans, using mathematical concepts, facts, and procedures to solve problems. On the other indicators, S2 performed poorly in interpreting solutions to solve problems and in evaluating solutions or the results of problem-solving. In general, S2 was able to identify problems and determine solutions to the given problems, as well as select and use concepts, facts, and procedures in solving mathematical problems. The challenge faced by S2 is their limited ability to evaluate the results obtained and relate them to the context of the given problem. This is evident from the interview results, where S2 appeared somewhat hesitant when answering questions about how to draw conclusions and connect them to other concepts. These results indicate that students in the low curiosity group possess fairly good mathematical literacy.

Mathematical literacy among students in the high-curiosity group is represented by S3. Students in the high-curiosity group demonstrated strong performance on four indicators of mathematical literacy, and one indicator showed fairly strong performance. S3 demonstrated strong performance in formulating problems as mathematical statements, identifying problems, and devising solution plans; applying mathematical concepts, facts, and procedures to solve problems; and interpreting solutions to solve problems. However, in the ability to evaluate solutions or the results of problem-solving, they achieved fairly good performance. This was revealed through the results of the mathematical literacy test and the interview. The steps to solve the problems were written down and carried out in a logical sequence; however, during the interview stage, S3 required additional guidance in evaluating the results of the given problem-solving tasks. Based on these results, it was concluded that students in the high curiosity group possess good mathematical literacy.

CONCLUSIONS

Based on the findings presented above, it can be concluded that students with low curiosity demonstrate poor mathematical literacy skills. Undergraduate students met only a small portion of the mathematical literacy indicators. Students with moderate curiosity demonstrated fairly good mathematical literacy skills, meeting three out of five mathematical literacy indicators. Students with high curiosity demonstrated good mathematical literacy skills, as they met all mathematical literacy indicators in the "good" and "fairly good" categories.

Further research is recommended to develop different models, media, and materials for different grade levels and across different affective domains to assess their consistency in improving students' mathematical literacy.

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