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Research Article

Analysis of Students' Behavior in Solving Mathematical Literacy Problems at the Junior High School Level

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Abstract: Background: Mathematical literacy is a key competency in 21st-century learning; however, Indonesian students' achievement remains low. Previous research has largely focused on cognitive aspects, while behavioral dimensions such as self-regulation, the use of mathematical tools, and self-confidence have not received adequate attention, even though these aspects play a crucial role in successful problem-solving. Methods: This study employed a qualitative approach using grounded theory. Participants consisted of 18 eighth-grade students from three public junior high schools in Yogyakarta, selected through stratified random sampling. Data were collected through a mathematics literacy test, semi-structured interviews, and observations, and analyzed using constant comparison until data saturation was reached. Results: The analysis revealed a new behavioral category, termed "semi-superior," situated between regular and superior behaviors. Self-regulation, the use of mathematical tools, and self-confidence interacted dynamically. Students with stronger self-regulation and higher self-confidence demonstrated more strategic and reflective approaches. A clear alignment was found between mathematical literacy proficiency and behavioral orientation. Implication: Mathematics instruction must integrate cognitive, metacognitive, psychomotor, and affective competencies. Future research should examine the socio-economic and technological factors that influence students' mathematical literacy behaviors.

Keywords: Junior High School; Mathematical Literacy; Mathematics Education; Problem-Solving Behavior; Student Behavior.

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1. Introduction

Mathematical literacy is a key competency in 21st-century learning, enabling students to formulate, apply, and interpret mathematics in real-life contexts (Arista & Mahmudi, 2020; Haeruman et al., 2024; Naser & Juandi, 2023). Beyond procedural knowledge, mathematical literacy involves critical, analytical, and reflective thinking skills that support sound decision-making in an increasingly complex, data-driven world (Ulya & Wardono, 2019). In daily life, mathematical literacy plays a crucial role in activities such as financial management, data interpretation, and problem-solving (Maslihah et al., 2020; Retnawati & Wulandari, 2019).

However, students' mathematical literacy in Indonesia remains relatively low. The Programme for International Student Assessment (PISA) 2022 ranked Indonesia 69th out of 81 countries, indicating that many students struggle to apply mathematical knowledge in contextual situations (OECD 2023). Previous studies in Yogyakarta also confirm that students face difficulties in solving context-based problems, largely due to teaching practices that emphasize procedural knowledge over conceptual understanding (Lubis et al., 2024; Nurjanah & Saputra, 2023). These findings highlight the gap between students' mathematical knowledge and their ability to use it meaningfully.

Most existing research focuses on students' mathematics literacy outcomes, particularly test performance, with limited attention to the behavioral processes underlying problem-solving. This creates a significant research gap, as students' success in mathematics literacy is determined not only by cognitive abilities but also by how they organize their thinking, utilize tools, and maintain self-confidence during problem-solving activities (Pratama, 2020; Siregar, 2025). These behavioral aspects can be conceptualized through three main dimensions: self-regulation, utilization of mathematical tools, and self-confidence (Muir et al., 2008).

From a theoretical perspective, self-regulation reflects students' self-regulation in managing cognitive processes during problem-solving, in line with self-regulated learning theory (Oppong et al., 2019; Zimmerman & Moylan, 2009). The use of mathematical tools represents the psychomotor dimension, which involves students' ability to effectively apply representations and resources (Harisman et al., 2025). Meanwhile, self-confidence is closely related to self-efficacy theory, which influences students' persistence and engagement in problem-solving (Bendol & Dalayap, 2025; Voica et al., 2020). Together, these dimensions illustrate the interaction between the cognitive, affective, and psychomotor domains in mathematical literacy behavior.

Although previous research has classified mathematical literacy behaviors into categories such as inferior, regular, and superior (Harisman et al., 2025), studies exploring how these behavioral dimensions interact and whether they consistently align with students' literacy achievements remain limited. Therefore, this study aims to expand the existing framework by examining students' behavioral orientations in a more integrated manner.

This study addresses two research questions: (1) How do junior high school students in Yogyakarta demonstrate behavioral orientations in solving mathematical literacy problems in terms of self-regulation, tool utilization, and self-confidence? (2) To what extent is there consistency between students' mathematical literacy achievement and their behavioral orientations?

By integrating behavioral analysis with literacy achievement, this study contributes to a more comprehensive understanding of mathematical literacy and provides insights for designing learning strategies that support students' cognitive, metacognitive, and affective development.

2. Literature Review

Istilah literasi berasal dari bahasa Inggris *literacy* yang pada awalnya dimaknai sebagai kemampuan membaca dan menulis, sedangkan secara etimologis berasal dari bahasa Latin *Literatus* yang berarti orang yang belajar. Dalam perkembangannya, literasi tidak hanya terbatas pada kemampuan membaca dan menulis, tetapi juga mencakup keterampilan berbicara, berhitung, serta memecahkan masalah sesuai dengan kebutuhan individu dalam lingkungan keluarga, pekerjaan, dan masyarakat. Dengan demikian, literasi dipahami sebagai kemampuan yang bersifat kontekstual dan menjadi dasar bagi seseorang untuk mengembangkan berbagai bidang ilmu, termasuk matematika (Abidin et al., 2021; Purpura et al., 2017).

Menurut *Assessment Framework PISA* yang disusun oleh OECD (2019), literasi matematika merupakan kapasitas individu untuk bernalar secara matematis, merumuskan, menggunakan, dan menafsirkan matematika dalam menyelesaikan berbagai persoalan yang muncul pada konteks dunia nyata. Kemampuan tersebut melibatkan penggunaan konsep, prosedur, fakta, dan alat matematika untuk mendeskripsikan, menjelaskan, serta memprediksi berbagai fenomena. Literasi matematika juga berfungsi membantu individu memahami peran matematika dalam kehidupan sehingga mampu mengambil keputusan yang logis, bertanggung jawab, dan sesuai dengan tuntutan masyarakat abad ke-21 (OECD, 2019).

Sejalan dengan kerangka PISA, kemampuan literasi matematika menitikberatkan pada penerapan pengetahuan matematika dalam berbagai situasi nyata, bukan sekadar penguasaan konsep secara teoritis. Kemampuan ini menjadi indikator penting dalam mengukur kesiapan peserta didik menghadapi tantangan kehidupan maupun perkembangan zaman. Melalui penilaian yang diterapkan di lebih dari 70 negara, PISA memberikan gambaran mengenai kemampuan siswa dalam mengaplikasikan matematika pada berbagai sistem pendidikan yang berbeda (Muhaimin et al., 2024; Stacey & Turner, 2015; Caponera et al., 2016).

Literasi matematika juga dipandang sebagai kemampuan yang mengintegrasikan penalaran matematis dengan pemahaman konseptual dan prosedural. Melalui kemampuan tersebut, siswa tidak hanya mampu menggunakan konsep matematika secara benar, tetapi juga memahami makna di balik setiap prosedur yang digunakan. Dengan demikian, siswa dapat menerapkan pengetahuan matematika secara bermakna dalam berbagai situasi, baik di lingkungan akademik maupun kehidupan sehari-hari (Kenney et al., 2005; Gellert et al., 2013; Connell, 2024; Scott et al., 2024).

Dalam konteks pembelajaran, literasi matematika berkaitan erat dengan kemampuan menggunakan bahasa untuk mengomunikasikan ide-ide matematika secara efektif. Guru maupun siswa dituntut mampu menjelaskan proses berpikir matematis, menganalisis berbagai strategi penyelesaian masalah, serta membangun pembelajaran yang mendorong partisipasi aktif seluruh siswa. Oleh karena itu, praktik literasi matematika perlu mengintegrasikan kemampuan literasi dengan pemahaman matematika agar pembelajaran menjadi lebih bermakna dan mendukung pengembangan kemampuan berpikir tingkat tinggi (Kenney et al., 2005; Moschkovich, 2024; Kane et al., 2024).

Berdasarkan berbagai pendapat tersebut, dapat disimpulkan bahwa kemampuan literasi matematika merupakan kemampuan individu untuk bernalar secara matematis, memformulasikan, menggunakan, dan menafsirkan konsep matematika dalam menyelesaikan masalah pada berbagai konteks kehidupan. Kemampuan ini tidak hanya mencakup penguasaan konsep dan prosedur, tetapi juga kemampuan mengomunikasikan ide matematika serta menggunakan hasil penalaran sebagai dasar dalam mengambil keputusan yang tepat.

Menurut OECD (2019), kerangka matematika PISA menilai literasi matematika siswa berusia 15 tahun melalui tiga aspek utama yang saling berkaitan, yaitu proses matematika, konten matematika, dan konteks. Proses matematika menggambarkan kemampuan siswa dalam menghubungkan situasi nyata dengan model matematika untuk memperoleh solusi. Konten matematika berkaitan dengan materi yang digunakan dalam penilaian, sedangkan konteks menunjukkan situasi kehidupan nyata yang menjadi dasar penyusunan soal. Ketiga aspek tersebut dirancang secara terpadu agar penilaian mampu mengukur kemampuan siswa dalam menerapkan matematika secara efektif pada berbagai kondisi nyata (OECD, 2019).

Dalam penyusunan instrumen PISA, distribusi butir soal dirancang secara proporsional untuk menggambarkan keseluruhan kemampuan literasi matematika. Sebanyak 25% soal berfokus pada kemampuan merumuskan situasi secara matematis, 50% menilai kemampuan menggunakan konsep matematika, fakta, prosedur, dan penalaran, sedangkan 25% sisanya mengukur kemampuan menafsirkan, menerapkan, dan mengevaluasi hasil matematika. Komposisi tersebut menunjukkan bahwa penilaian PISA lebih menekankan kemampuan menggunakan matematika dalam menyelesaikan masalah dibandingkan sekadar menguasai konsep secara teoritis (OECD, 2019).

Perilaku siswa merupakan seluruh aktivitas fisik maupun mental yang dilakukan sebagai respons terhadap suatu kondisi atau permasalahan dengan tujuan mencapai keberhasilan belajar. Perilaku ini mencakup tiga domain utama, yaitu kognitif, psikomotorik, dan afektif. Domain kognitif berkaitan dengan pengetahuan serta proses berpikir, domain psikomotorik berhubungan dengan keterampilan motorik yang dipengaruhi sistem neuromuskuler, sedangkan domain afektif menggambarkan sikap, emosi, dan perasaan yang ditunjukkan siswa selama proses pembelajaran (Gunawan et al., 2019; Menix, 1996; Muir et al., 2008; Harisman et al., 2021; Harisman & Khairani, 2021; Rohati et al., 2022; Rohati et al., 2023).

Perilaku muncul sebagai respons terhadap rangsangan yang diterima siswa, terutama ketika mereka menghadapi suatu masalah yang harus diselesaikan. Dalam proses tersebut, siswa menampilkan berbagai tindakan yang dipengaruhi oleh pengetahuan, sikap, emosi, nilai, adat, etika, serta lingkungan sosial seperti persuasi dan kekuasaan (Muir et al., 2008; Yulia et al., 2019). Oleh karena itu, perilaku siswa merupakan hasil interaksi antara karakteristik individu dengan lingkungan tempat mereka belajar (Porter, 2020).

Perkembangan penelitian menunjukkan bahwa kajian perilaku siswa tidak lagi hanya berorientasi pada identifikasi gangguan atau pembangkangan, tetapi juga memanfaatkan teknologi informasi dan *machine learning* untuk menganalisis pola perilaku secara lebih objektif. Pendekatan ini membantu guru dan sekolah dalam memberikan dukungan pembelajaran yang lebih personal sehingga mampu meningkatkan keterlibatan, kepuasan, dan hasil belajar siswa (Millei & Petersen, 2015; Su, 2021; Shah & Bashir, 2022). Selain itu, aspek perilaku, ketekunan, dan prestasi akademik juga telah lama menjadi dasar dalam pemberian dukungan maupun disiplin di lingkungan pendidikan (Drach, 2022; Strickland, 2022). Pengamatan terhadap perilaku siswa dapat dilakukan secara sistematis menggunakan kode observasi terstruktur sehingga menghasilkan data yang lebih objektif dan terukur (Volpe et al., 2023).

Dalam pembelajaran matematika, siswa dihadapkan pada berbagai soal literasi matematis yang menuntut kemampuan memahami konteks, menganalisis informasi, serta menentukan strategi penyelesaian. Selama proses tersebut siswa menampilkan serangkaian perilaku yang menggambarkan cara mereka berpikir dan menyelesaikan masalah. Oleh karena itu, perilaku siswa dalam menyelesaikan soal literasi matematis menjadi aspek penting untuk dikaji karena mampu memberikan gambaran yang lebih lengkap mengenai proses berpikir siswa dibandingkan hanya mengukur hasil tes. Kritik terhadap penelitian yang hanya berfokus pada tes kemampuan literasi matematis menyatakan bahwa pendekatan tersebut belum mampu menjelaskan bagaimana proses berpikir siswa ketika menyelesaikan masalah (Goldin, 1984; Krutetskii, 1976 dalam Fitzpatrick, 1994).

Berbagai penelitian telah mengembangkan klasifikasi perilaku siswa dalam pembelajaran matematika. Gunawan et al. (2019) mengembangkan rubrik perilaku pemahaman konsep matematika yang dipengaruhi oleh kepemilikan pengetahuan, kontrol, keyakinan, dan afektif, kemudian mengelompokkan perilaku menjadi tiga kategori, yaitu *instrumentalis, semi-rasionalis,* dan *relasional.* Selanjutnya, Rohati et al. (2022) mengembangkan rubrik perilaku penalaran matematis yang terdiri atas kategori *imitatif, algoritma,* dan *kreatif.* Pada aspek pemecahan masalah, Muir et al. (2008) mengelompokkan perilaku siswa ke dalam kategori *naif, rutin,* dan *canggih.* Klasifikasi tersebut kemudian digunakan kembali oleh Harisman dan Khairani (2021) untuk membandingkan perilaku siswa pada pembelajaran langsung dan pembelajaran daring, dengan hasil bahwa ketiga kategori tersebut tetap muncul pada kedua jenis pembelajaran. Penelitian berikutnya oleh Harisman et al. (2021) mengembangkan klasifikasi tersebut menjadi empat kategori, yaitu *naif, rutin, semi canggih,* dan *canggih.*

Penelitian lain juga menunjukkan bahwa perilaku pemecahan masalah dipengaruhi oleh karakteristik siswa. Adhimah dan Ekawati (2020) menemukan bahwa siswa SMK dengan kecemasan matematika tinggi cenderung menunjukkan perilaku *Direct Translation Approach not proficient (DTA-np)*, sedangkan siswa dengan kecemasan rendah lebih banyak menunjukkan perilaku *Meaning Based Approach full context (MBA-fc).* Temuan ini menunjukkan bahwa faktor afektif turut memengaruhi strategi penyelesaian masalah matematika.

3. Materials and Method

This study employs a qualitative approach using grounded theory to examine students' behavior in solving mathematical literacy problems. Grounded theory was chosen because it allows for the development of a theory based on empirical data and the participants' experiences (Creswell, 2015). This approach allows for a deep understanding of students' cognitive, affective, and behavioral processes during problem-solving, particularly those related to self-regulation, the use of mathematical tools, and self-confidence.

Participants and Sampling

This study employed a multistage random sampling technique, in which the population was divided into homogeneous subgroups (strata) and samples were selected at random from each group to ensure proportional representation (Fraenkel & Wallen, 2009). These groups were formed based on relevant characteristics, such as academic achievement (Hossan et al., 2023; Mullis, I.V.S., Martin, M.O., Foy, P., & Arora, 2012).

In this study, the initial grouping of schools was based on academic achievement data. Given that the National Examination (UN) has not been administered nationally in Indonesia since 2020 and has been replaced by the Minimum Competency Assessment (AKM), this study uses UN scores from the five preceding years as historical data representing schools' academic performance prior to the policy change. This data is supplemented with more recent school-level academic records to ensure that the classification remains relevant to current conditions. This approach is applied to maintain data continuity while accommodating changes in education policy.

School classification was determined using descriptive statistics (mean = 78.19; SD = 12.61), resulting in three categories: high ($x > 90.80$), moderate ($65.58 \leq x \leq 90.80$), and low ($x < 65.58$). From the 16 public junior high schools in Yogyakarta City, one school from each category was randomly selected: SMPN 5 Yogyakarta (high), SMPN 4 Yogyakarta (moderate), and SMPN 15 Yogyakarta (low).

This study was conducted during the second semester of the 2023–2024 academic year. Six students were selected from each school, resulting in a total of 18 participants. This sample size is considered appropriate for qualitative research using a grounded theory approach, which emphasizes data depth over quantity (Creswell, 2015; Harisman et al., 2021, 2023).

Student selection at each school was conducted using purposive sampling accompanied by clear inclusion and exclusion criteria. Inclusion criteria included: (1) eighth-grade students, (2) students who had completed a mathematics literacy test developed by the researcher, and (3) students willing to participate in follow-up interviews. Exclusion criteria included students who did not complete the test or refused to participate in the interviews.

Students were grouped into high, medium, and low ability levels based on test results using the extreme-groups method (Kelley, 1939), in which the top 27% of students were categorized as high ability, the middle 46% as medium ability, and the bottom 27% as low ability. Two students from each category were selected from each school.

In addition, participants were selected based on their communication skills and their willingness to express their thoughts during the interviews. This ensures that the selected students represent a range of ability levels and provide rich data for analyzing mathematical literacy behaviors.

Research Instruments

This study utilized several instruments: (1) a mathematics literacy test consisting of 20 items, (2) a semi-structured interview guide, and (3) an observation sheet. The test consists of 20 multiple-choice questions covering content domains such as number patterns, algebra (SPLDV), geometry (Pythagorean theorem), and statistics, designed to assess understanding, application, and reasoning in real-life contexts.

Instrument validation was conducted by three mathematics education experts. The validation results indicated that all items were relevant and appropriate, with minor revisions to wording and contextual clarity. The interview guide was also validated to ensure alignment with the three behavioral dimensions under study.

Data were collected through written tests, followed by semi-structured interviews and classroom observations. The interviews focused on students' thinking processes, strategies, and confidence in problem-solving. Observations were conducted to capture students' actual behaviors during problem-solving.

Data Analysis Techniques

The data were analyzed using the constant comparison method through three stages: open coding, axial coding, and selective coding (Corbin & Strauss, 1990; Umanailo, 2018). In the open coding stage, data is broken down into initial concepts. Axial coding is used to identify relationships between categories, particularly between self-control, tool use, and self-confidence. Selective coding integrates these categories into a coherent behavioral orientation framework.

Analysis was conducted iteratively over several cycles until theoretical saturation was reached, marked by the absence of new categories (Akkaya, 2023). To ensure validity, triangulation between test results, interviews, and observations was applied, and coding consistency was checked through peer discussions.

4. Results and Discussion

This study was conducted at three schools: SMPN 5 Yogyakarta, SMPN 4 Yogyakarta, and SMPN 15 Yogyakarta. Based on the mathematics literacy test, students' scores were analyzed to determine their proficiency levels and select participants for follow-up interviews. The mean score was 67.31, with a standard deviation of 24.38. Based on these results, students were classified into high, medium, and low categories using a predetermined cutoff score.

Table 1. Descriptive Statistics and Cut-off Scores of Mathematical Literacy

Statistic	Score
High Category	$x > 91.69$
Medium Category	$42.93 \leq x \leq 91.69$
Low Category	$x < 42.93$

Note: The threshold values are calculated using the mean ± standard deviation.

Table 2. Distribution of Students Based on Mathematical Literacy Levels

School	Total Students	High	Medium	Low
SMPN 5 Yogyakarta	28	2	23	3
SMPN 4 Yogyakarta	31	14	13	4
SMPN 15 Yogyakarta	34	2	18	14

Note: The data represents students from three junior high schools in Yogyakarta

From each school, six students were selected: two high-ability (T), two medium-ability (S), and two low-ability (R) students. These participants were then analyzed to explore their mathematical literacy behavior. Based on this data, the grouping of mathematical literacy can be seen in Table 3.

Table 3. Selected Research Participants

No	SMP N 5 Yogyakarta	SMP N 4 Yogyakarta	SMP N 15 Yogyakarta
1	T1 (S-1)	T1 (S-2)	T1 (S-3)
2	T2 (S-1)	T2 (S-2)	T2 (S-3)
3	S1 (S-1)	S1 (S-2)	S1 (S-3)
4	S2 (S-1)	S2 (S-2)	S2 (S-3)
5	R1 (S-1)	R1 (S-2)	R1 (S-3)
6	R2 (S-1)	R2 (S-2)	R2 (S-3)

Note: T = High ability, S = Medium ability, R = Low ability

S-1 = School 1 (SMPN 5), S-2 = School 2 (SMPN 4), S-3 = School 3 (SMPN 15)

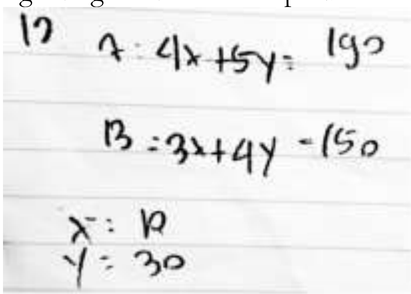
To provide a clearer and more focused analysis, this section presents one representative case study from each competency category, followed by a summary of the overall patterns. This analysis focuses on cognitive aspects, specifically students' ability to devise strategies for problem-solving.

Low-Ability Students (Inferior Category)

Students with low ability generally experience significant difficulty in formulating problem-solving strategies. They often struggle to understand the problem, identify relevant information, and determine the appropriate steps for solving it. Some students leave questions unanswered, while others rely solely on guesswork without applying the appropriate mathematical concepts.

For example, one student (R1S-1) attempted to answer by directly substituting arbitrary values without using systematic methods such as elimination or substitution to solve a system of linear equations. During the interview, the student admitted to guessing the answer and not recalling the relevant methods.

These findings indicate that students with low ability tend to rely on a trial-and-error approach and lack structured strategies. Overall, they require more guidance in understanding concepts and developing effective problem-solving strategies. The following is presented in Figure 1 and Table 5 in the form of an answer sheet and an excerpt from the interview with R1S-1 regarding the solution to problem 12.



12.
A = 4x + 5y = 190

B = 3x + 4y = 150

X = 10

Y = 30

Figure 1. Mathematical Representation R1S-1 for problem Twelve

Table 4. Results of Student Interviews R1S-1Question Twelve

Question	Student's Answer	Reduction Results
How do you solve this problem?	I'll just enter	Students show a direct approach by entering grades without considering systematic steps in solving problems. This indicates the use of less than optimal strategies
Enter the double pick?	I just put the x is 10 and the y is 30	Students express the action taken by entering values for the X and Y variables. This indicates that

		they are taking quick steps, but not through an in-depth analysis of the problem.
Then what is the answer?	The answer is A 50 and 140	Students give answers without understanding the exact process or formula, only based on filling in directly to the answer choices. This reflects a lack of understanding in the underlying concept.
Can you explain how you get x=10 and y=30?	I don't know, I just guessed	Learners' inability to explain how they got X and Y grades indicates that they are not using the right strategies in solving problems, as well as a reliance on guesswork.
Do you still remember the SPLDV elimination and substitution method?	Forget	Students do not remember the SPLDV elimination and substitution methods, showing a lack of mastery of strategies that should be used to solve the two-variable linear equation system (SPLDV).
Data Reduction Conclusion	Students seem to lack the right strategies to solve problems. They tend to rely on guesswork and do not apply mathematical methods that have been learned, such as elimination and substitution. This shows the need to strengthen the understanding of concepts and the application of strategies that are more effective in solving mathematical problems.	

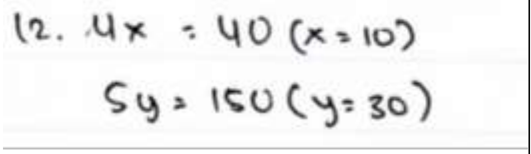
Medium-Ability Students (Regular Category)

Students with average ability demonstrate better skills in understanding questions and applying basic strategies. They are generally able to choose the appropriate approach and arrive at the correct answer. However, the strategies they use tend to be simple and procedural in nature, such as matching answers on multiple-choice questions rather than analyzing the questions thoroughly.

For example, a student representing this group (S1S-1) used basic operations and a matching strategy to solve the problem correctly. Although effective, this approach reflects limited exploration of alternative strategies.

Overall, students with moderate ability demonstrate adequate problem-solving skills but still require support to develop deeper and more flexible strategic thinking.

Figure 2 and Table 6 present the results of the mathematics literacy test as well as excerpts from interviews conducted with the regular student S1S-1.



1
2. 4x = 40 (x = 10)

5y = 150 (y = 30)

Figure 2. Mathematical Representation S1S-1 for problem Twelve

Tabel 5. Results of S1S-1 Student InterviewsQuestion Twelve

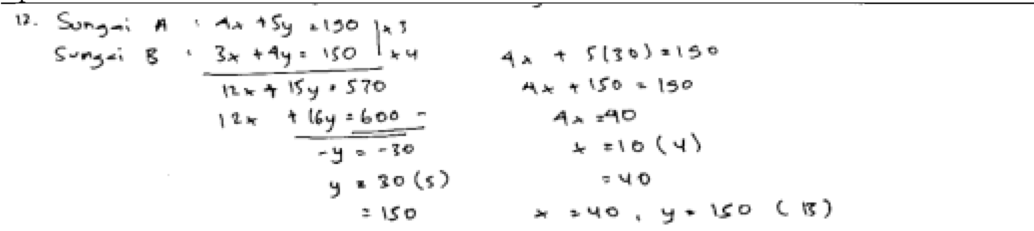
Question	Students' Answers	Reduction Result
How do you solve the problem of twelve?	I'm just matching the answers, sis. I just need to multiply them.	Learners demonstrate that they use a simple and straightforward approach in problem-solving, namely by matching answers. This reflects a strategy that may be efficient for multiple-choice questions but is less profound in problem-solving.
Conclusion Data Reduction	learners tend to rely on simple and less varied strategies in solving problems. Although they may use basic operations, their approach does not reflect the exploration or development of more in-depth and structured strategies. This suggests the need for further development in concept understanding and application of various mathematical problem-solving strategies.	

High-Ability Students (Superior Category)

High-ability students demonstrate strong skills in designing and applying problem-solving strategies. They are able to identify, formulate, and solve problems systematically using appropriate methods, such as elimination and substitution.

A student representing this group (T1S-1) applied the elimination method to determine one variable, then used substitution to determine the other variable. The student also verified their answer and was able to propose alternative strategies during the interview.

These findings indicate that high-ability students not only apply effective strategies but also demonstrate flexibility in considering various approaches. Their mathematical thinking is more structured, adaptive, and reflective. The following is presented in Figure 3 and Table 7 in the form of an answer sheet and excerpts from T1S-1's interview regarding the solution to problem twelve.



12. Sungai A: $4x + 5y = 190$ | X3
Sungai B: $3x + 4y = 150$ | X4

$12x + 15y = 570$
$12x + 16y = 600$
$-y = -30$
$Y = 30 (5)$
$= 150$

$4x + 5(30) = 190$
$4x + 150 = 190$
$4x = 40$
$x = 10 (4)$
$= 40$
$x = 40, y = 150$ (B)

Figure 3. T1S-1 Mathematical Representation for the Twelve problem

Table 6. Results of Student Interviews T1S-1Question Twelve

Question	Student's Answer	Reduction Results
How do you do the problem?	So, river A is 4x+5y=190, river B is 3x+4y=150. Now so that we get one variable, we multiply it by river A times 3 and river B times 4. Let the x disappear. After multiplying, river A is 12x+15y=570 and river B is 12x+16y=600. Well, it just needs to be reduced. 570 minus 600 is min 30 so we get y = 30	Students choose an elimination strategy by multiplying the equation to eliminate variables, which shows their understanding of problem-solving methods.
Now how to find out the value of x?	We already know the y value, so we put it in river equation A 4x+5y=190. Then 4x+150=190 and get the value x=10.	Students use substitution strategies after finding yyy values. This shows flexibility in the methods used to solve problems.
Continue. Done?	Not yet. The only thing left is the A river, 4x+5y=190, 4 times 10 = 40 and 5 times 30 = 150.	Learners demonstrate the ability to verify the result by substituting values into equations, which is an important part of the problem-solving process.
So, what can you get?	B	Learners conclude answers clearly, reflecting their ability to infer the results of the steps that have been taken in problem-solving.
Data Reduction Conclusion	Learners demonstrate an ability to select and use a variety of strategies to solve problems, from the selection of elimination methods to substitution and verification of results, reflecting good mathematical thinking skills.	

Emergence of Semi-Superior Category

The analysis indicates that the existing classifications (low, moderate, high) do not fully capture the variation in student behavior. An additional category, "semi-high," has emerged to describe students who exhibit characteristics falling between the moderate and high levels.

Students in this category are able to apply appropriate strategies but not consistently. They sometimes demonstrate flexibility and deeper understanding, yet at other times rely on simpler approaches. This indicates a transitional stage in mathematical literacy behavior.

These findings indicate that the semi-superior category represents a transitional stage in students' mathematical literacy behavior. To gain a deeper understanding of this transition, the analysis was expanded to examine students' behavior from various perspectives. The following section presents the results of the analysis of students' mathematical literacy behavior in cognitive aspects. Table 7 below provides a description of mathematical literacy behavior in the cognitive aspect.

Table 7. Students' Mathematical Literacy Behavior (Cognitive Aspect)

Behavior Category	Student Code	Percentage
Inferior	R1S-1, R1S-2, R1S-3, R2S-3, S1S-3 (←)	27.78%
Regular	S1S-1, R2S-1 (→), R2S-2 (→)	16.66%
Semi-Superior	S2S-1 (→), T2S-2 (←), S2S-2 (→), S2S-3 (→), T2S-3 (←)	27.78%
Superior	T1S-1, T2S-1, T1S-2, S1S-2 (→→), T1S-3	27.78%

Note: R = low ability, S = medium ability, T = high ability (based on test results)
← = indicates that the student's behavior is lower than their test-based ability
→ = *indicates that the student's behavior is higher than their test-based ability*

Based on Table 7, students with low (R), moderate (S), and high (T) literacy levels exhibit different patterns of cognitive behavior. Students with low ability are mostly in the inferior category, indicating limited ability to devise problem-solving strategies, with only a slight increase to the regular level. Students with moderate abilities show greater variation, with many of them reaching the semi-superior category, indicating the emergence of strategic thinking but not yet consistently. Students with high abilities are mostly in the superior category; however, some show slightly lower performance, indicating inconsistency in applying strategies. Overall, the relatively even distribution among the inferior, semi-superior, and superior categories (27.78%) and the smaller proportion in the regular category (16.66%) indicate a polarization of students' cognitive behaviors, with fewer students consistently performing at an intermediate level. The following table presents the results of students' mathematical literacy behaviors in the aspect of self-regulation.

Table 8. Students' Mathematical Literacy Behavior in the Aspect of Self-Control

Behavior Category	Student Code	Percentage
Inferior	R1S-2, R1S-3, R2S-3	16.67%
Regular	S2S-1, R2S-1 (→), R2S-2 (→), S1S-3	22.22%
Semi-Superior	R1S-1 (→), T1S-2 (←), S2S-2 (→), T2S-3 (←)	22,22%
Superior	T1S-1, T2S-1, S1S-1(→), T2S-2, T1S-3, S1S-2(→), S2S-3(→)	38,89%

Note: R = low ability, S = medium ability, T = high ability (based on test results)
← = indicates that the student's behavior is lower than their test-based ability
→ = *indicates that the student's behavior is higher than their test-based ability*

Based on Table 8, students with different literacy levels exhibit distinct patterns. Students with low proficiency are mostly in the inferior category, indicating limited metacognitive awareness, although some of them show slight improvement to higher levels. Students with moderate proficiency exhibit a wider range of variation, with many of them reaching the regular and superior categories, indicating the emergence of self-regulation skills. Students with high proficiency are mostly in the superior category, reflecting strong metacognitive control, although some of them show slightly lower performance. Overall, the dominance of the superior category (38.89%) indicates that many students have developed good self-control; however, the presence of students in lower categories suggests that further support is still needed to improve consistency across all levels. The following table presents the results of students' mathematical literacy behaviors in the Mathematical Tools aspect.

Table 9. Students' Mathematical Literacy Behavior in the Mathematical Tools Aspect

Behavior Category	Student Code	Percentage
Inferior	R1S-1, R2S-1, S2S-2, R2S-2, S1S-3, R1S-3, R2S-3, T2S-3	44.44%
Regular	T1S-1 (←), T2S-1 (←), S2S-1, T1S-2 (←), T2S-2 (←), S1S-2, S2S-3, T1S-3 (←)	44.44%
Semi-Superior	S1S-1 (→), R1S-2 (→)	11.12%

Superior	– (no students)	0%

Note: R = low ability, S = medium ability, T = high ability (based on test results)
(→) indicates behavior higher than test-based ability
(←) indicates behavior lower than test-based ability

Based on Table 9, the majority of students are concentrated in the below-average and average categories (44.44% each), indicating that their use of mathematical tools is generally limited to basic and intermediate levels. Only a small proportion of students reached the above-average category (11.12%), and none reached the advanced level. Students with low proficiency tend to rely on simple tools, while students with intermediate and high proficiency show some variation but have not yet fully mastered the integration of mathematical tools. These findings suggest that, overall, students still need support in effectively utilizing and combining mathematical tools for problem-solving. The following table presents the results of students' mathematical literacy behaviors regarding self-confidence (belief).

Table 10. Students' Mathematical Literacy Behavior in the Aspect of Confidence (Belief)

Behavior Category	Student Code	Percentage
Inferior	R2S-1, R1S-3, R2S-3	16.67%
Regular	S2S-1, R1S-1 (→), R1S-2 (→), R2S-2 (→), S1S-3, T1S-2 (←)	33.33%
Semi-Superior	T1S-1 (←), S1S-1 (→), S2S-2 (→), T2S-3 (←), S2S-3 (→)	27.78%
Superior	T2S-1, T2S-2, S1S-2 (→), T1S-3	22.22%

Note: R = low ability, S = medium ability, T = high ability (based on test results)
(→) indicates behavior higher than test-based ability
(←) indicates behavior lower than test-based ability

Based on Table 10, students' confidence levels in mathematical literacy show varying patterns across ability levels. Most students fall into the regular and semi-superior categories, indicating that their confidence is developing but not yet stable. Students with low ability tend to remain in the inferior category, while students with moderate ability show greater variation across these categories. Students with high ability are mostly in the superior category, although some of them show slightly lower levels of confidence. Overall, this distribution indicates that students' confidence in solving mathematical problems still needs to be strengthened, especially for those in the low and intermediate categories. This pattern of behavior is illustrated in the following table:

Table 11. Rubric on the Behavior of Junior High School Students in Yogyakarta City

Aspect	Indicator	Inferior	Regular	Semi-Superior	Superior
Cognitive	Communication	Presents <30% of problems, processes, and solutions	Presents 50–70%	Presents 70–90% with minor gaps	Presents >90% accurately
	Mathematising	Unable to transform real-world problems	Able with errors	Able with few errors	Accurate transformation
	Representation	Only represents given data	Represents into one form	Represents into multiple forms with minor errors	Represents into various forms accurately
	Reasoning & Argument	Only describes information	Connects with errors	Mostly valid reasoning	Fully logical and valid arguments
	Devising Strategies	Uses incorrect strategy	Uses one correct strategy	Uses multiple strategies with minor errors	Flexible and effective strategies
	Symbolic/Formal Language	>50% errors	<30% errors	10–20% errors	Accurate and appropriate
	Control (Metacognition)	Not evident	Verbal only	Verbal & written (inconsistent)	Consistent and in-depth

Psychomotor	Using Mathematical Tools	Uses simple tools only	Uses basic technology	Uses and integrates some features	Integrates multiple tools effectively
Affective	Belief (Confidence)	Not confident	Partially confident	Mostly confident with minor doubts	Fully confident and accurate

Discussion

This study provides insights into the mathematical literacy behaviors of eighth-grade students at junior high schools in Yogyakarta. The findings highlight variations in students' cognitive aspects, self-control, use of mathematical tools, and self-confidence when solving mathematical literacy problems. Rather than making broad generalizations, these findings should be understood as contextual patterns derived from a limited sample.

One important contribution of this study is the identification of a "semi-superior" behavioral orientation, which expands upon the categories proposed by (Harisman et al., 2025). This category does not replace existing classifications but enhances them by capturing students whose performance exceeds the regular level yet does not consistently reach the superior level. Compared to regular students, who can apply strategies only in a limited or procedural manner, semi-superior students demonstrate more flexible thinking but still exhibit inaccuracies or inconsistencies. In contrast, superior students demonstrate consistent accuracy, flexibility, and the ability to evaluate various strategies. Thus, the semi-superior category represents an intermediate yet unstable stage of development in mathematical literacy behavior.

From a theoretical perspective, these findings can be interpreted using Zimmerman's theory of self-regulated learning, particularly in explaining differences in self-control. Students in the inferior category demonstrated limited metacognitive awareness, difficulty managing time, and low perseverance, indicating weak self-regulation (Muijs & Bokhove, 2020; Singaravelu & Chandrakumari, 2025). Regular students begin to exhibit emerging self-regulatory behaviors, such as monitoring errors and managing strategies, though not consistently. Superior students demonstrate strong self-regulation, including effectively planning, monitoring, and evaluating their problem-solving processes.

Similarly, differences in self-confidence can be understood through Bandura's self-efficacy theory (Albert, 1997). Students with low self-confidence tend to avoid challenging problems and rely on guesswork, while students with higher self-confidence are more willing to engage, persevere, and apply strategies (Kloosterman, 1988; Parsons et al., 2009; Sabug, 2023). However, these findings also suggest that self-confidence alone is not sufficient; it must be supported by strong cognitive and metacognitive skills to produce optimal performance (Fleming, 2024; Tachie, 2019).

In terms of the use of mathematical tools, most students are still at the basic or intermediate level, with limited integration of technological tools. This indicates that students' opportunities to interact with tools such as dynamic mathematics software remain limited. From a learning perspective, this aligns with the idea that the use of tools is not merely a technical skill but also part of strategic competence, which develops through targeted practice and meaningful integration into learning activities (Drejer & Riis, 1999; Mahmoud, 2023; Ramaila & Molwele, 2022).

Overall, these findings suggest that self-regulation, self-confidence, and the use of mathematical tools are interrelated factors that influence students' mathematical literacy. Students with better self-regulation tend to demonstrate higher self-confidence, and those who use tools effectively are more likely to solve problems efficiently (Grothérus et al., 2019; Landrum, 2020). These results support previous studies emphasizing the importance of integrating cognitive, affective, and technological aspects into mathematics learning (Chiu et al., 2022; Daher, 2013; Ni et al., 2018).

However, this study has several limitations. The relatively small sample size (18 students) from only three schools in Yogyakarta limits the generalizability of the findings. Furthermore, as a basic theoretical study, the results are context-dependent and must be interpreted within a specific educational setting. The use of national exam data for school classification may not fully reflect students' current abilities due to policy changes, and reliance on interviews and observations may introduce potential researcher bias.

Future research is recommended to involve a larger and more diverse sample, explore additional factors such as socioeconomic background and access to technology, and examine the effectiveness of learning strategies, such as problem-based learning and technology-integrated learning, in improving students' mathematical literacy.

5. Conclusion

This study identified four categories of student behavioral orientations in solving mathematical literacy problems among junior high school students in Yogyakarta: inferior, regular, semi-superior, and superior. This newly identified semi-superior category describes students who exhibit behavior that exceeds the regular level but have not yet consistently reached the superior level. The findings indicate that self-regulation, the use of mathematical tools, and self-confidence are closely interrelated and align with students' levels of mathematical literacy. Students with stronger self-regulation, more effective use of mathematical tools, and higher self-confidence tend to exhibit more strategic, reflective, and consistent problem-solving behaviors. Conversely, students with lower levels in these aspects tend to struggle with solving contextual math problems. These findings imply that mathematics teachers should design learning activities that explicitly foster metacognitive self-regulation, such as self-monitoring checklists, gradually introduce technological tools like GeoGebra to strengthen mathematical representations, and build students' self-confidence through supported experiences of success. Such teaching strategies are essential for supporting the comprehensive development of students' mathematical literacy.

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