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Analysis of Students' Mathematical Comprehension and Problem-Solving Abilities Based on the Level of Metacognitive Awareness

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ABSTRACT

This study aims to describe students' mathematical comprehension ability and mathematical problem-solving ability based on their level of metacognitive awareness in Social Arithmetic material. This study employed a qualitative descriptive approach involving 26 eighth-grade students of SMPN 1 Ciwaringin, Cirebon, selected purposively. Data were collected through a metacognitive awareness questionnaire, a mathematical comprehension test, and a mathematical problem-solving test. Data analysis was conducted by classifying students into high, medium, and low categories based on the mean and standard deviation. A one-way ANOVA was then conducted for each mathematical ability, after the data met the assumptions of normality and homogeneity of variance, to test whether the differences across metacognitive awareness categories were statistically significant. The results showed that students with a high level of metacognitive awareness demonstrated better mathematical comprehension and problem-solving abilities than students in the medium and low categories. The high group achieved high-category performance in both abilities, the medium group was in the medium category, and the low group was in the low category. The ANOVA results showed a statistically significant difference in mathematical comprehension ability across metacognitive awareness categories ($p = 0.000$), while the difference in mathematical problem-solving ability was not statistically significant ($p = 0.266$). Therefore, metacognitive awareness plays an important role in supporting students' mathematical comprehension ability, while its role in problem-solving ability requires further investigation.

ABSTRAK

Penelitian ini dilakukan untuk menggambarkan kemampuan pemahaman matematis serta kemampuan pemecahan masalah matematis yang dimiliki siswa berdasarkan tingkat metacognitive awareness pada materi Aritmatika Sosial.

Kata Kunci:
Kemampuan pemahaman matematis;
Kemampuan pemecahan masalah matematis;
metacognitive awareness;

Penelitian ini menggunakan pendekatan deskriptif kualitatif dengan subjek sebanyak 26 siswa kelas VIII SMPN 1 Ciwaringin, Cirebon, yang dipilih secara purposif. Data penelitian diperoleh melalui angket *metacognitive awareness*, tes kemampuan pemahaman matematis, serta tes kemampuan pemecahan masalah matematis. Selanjutnya, data dianalisis dengan mengelompokkan siswa ke dalam kategori tinggi, sedang, dan rendah berdasarkan nilai rata-rata serta standar deviasi. Selanjutnya dilakukan uji One-Way ANOVA untuk masing-masing kemampuan matematis, setelah data memenuhi asumsi normalitas dan homogenitas, guna menguji apakah perbedaan antarkategori metacognitive awareness bersifat signifikan secara statistik. Hasil penelitian memperlihatkan bahwa siswa dengan tingkat *metacognitive awareness* yang tinggi cenderung memiliki kemampuan pemahaman matematis dan pemecahan masalah yang lebih baik dibandingkan siswa pada kategori sedang dan rendah. Kelompok dengan kategori tinggi menunjukkan hasil yang tinggi pada kedua kemampuan tersebut, sementara kelompok sedang berada pada kategori sedang dan kelompok rendah memperoleh hasil pada kategori rendah. Hasil uji ANOVA menunjukkan perbedaan yang signifikan secara statistik pada kemampuan pemahaman matematis antarkategori metacognitive awareness (p = 0,000), sementara perbedaan pada kemampuan pemecahan masalah matematis tidak signifikan secara statistik (p = 0,266). Dengan demikian, metacognitive awareness berperan penting dalam mendukung kemampuan pemahaman matematis siswa, sedangkan perannya terhadap kemampuan pemecahan masalah masih memerlukan kajian lebih lanjut.

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INTRODUCTION

Mathematical skills are one of the important competencies that students must have in dealing with various problems in daily life. In mathematics learning, mathematical comprehension skills and mathematical problem-solving skills are two main interrelated skills. Mathematical understanding plays a role as a basis in building problem-solving skills, while the problem-solving process can deepen students' understanding of mathematical concepts[1]. Therefore, these two abilities need to be developed in a balanced manner in the mathematics learning process.

Various national and international assessment results show that the mathematical ability of Indonesian students still needs serious attention, especially

[1] Irlin Cahyani's daughter, *The Relationship between Concept Understanding and Problem Solving in Mathematics Lesson Class VII Mtsn 3 Agam*, 2020.

in the aspects of conceptual understanding and contextual problem solving[2]. The results of the Programme for International Student Assessment (PISA) also show that the mathematical ability of Indonesian students is still in the low category, especially in the aspect of reasoning and context-based problem-solving[3]. This condition indicates that students not only have difficulty in understanding mathematical concepts, but also in managing the thought process when solving problems. This shows the importance of metacognitive aspects in mathematics learning.

Metacognitive awareness is the ability of individuals to be aware, monitor, and control their own thought processes. Flavell explained that metacognition is related to a person's ability to understand the thought process and determine the right strategy when completing a task[4]. Schraw and Dennison then developed the concept through the Metacognitive Awareness Inventory (MAI) which includes the dimensions of cognition knowledge and cognition regulation[5]. Students with good metacognitive awareness tend to be able to plan completion strategies, monitor thought processes, and evaluate results obtained more effectively[6].

The cognition knowledge and cognition regulation dimensions described above are conceptually relevant to mathematics learning, since comprehending mathematical concepts and solving mathematical problems both require students to construct meaning, plan an appropriate strategy, and evaluate their own thinking process. Hiebert and Carpenter state that mathematical understanding occurs when students are able to construct meaningful relationships between concepts[7]. According to Polya, mathematical problem solving consists of four main stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the obtained solution[8]. Both of these abilities require good thinking regulation so that students are able to choose the appropriate strategy and evaluate

[2] Siti Mawaddah And Hana Anisah, *Students' Mathematical Problem-Solving Ability in Mathematics Learning Using the Generative Learning Model in Junior High School*, 2022.
[3] OECD, *Pisa 2022 Assessment And Analytical Framework*, Pisa (OECD Publishing, 2023), Https://Doi.Org/10.1787/Dfe0bf9c-En.
[4] John H. Flavell, 'Metacognition And Cognitive Monitoring: A New Area Of Cognitive–Developmental Inquiry.', *American Psychologist* 34, no. 10 (October 1979): 906–11, Https://Doi.Org/10.1037/0003-066x.34.10.906.
[5] Gregory Schraw And Rayne Sperling Dennison, 'Assessing Metacognitive Awareness', *Contemporary Educational Psychology* 19, no. 4 (October 1994): 460–75, Https://Doi.Org/10.1006/Ceps.1994.1033.
[6] Nurlaila Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability', *Pythagoras Journal of Mathematics Education* 16, no. 1 (September 2021): 44–58, Https://Doi.Org/10.21831/Pg.V16i1.34509.
[7] Risma Nurul Auliya, 'Mathematics Anxiety and Mathematical Comprehension', *Formative: Scientific Journal of Mathematics and Natural Sciences Education* 6, No. 1 (April 2016), Https://Doi.Org/10.30998/Formatif.V6i1.748.
[8] Alan H. Schoenfeld, 'Politics, Problem Solving, and Education', *Mathematics Magazine* 60, no. 5 (December 1987): 283–91, Https://Doi.Org/10.1080/0025570x.1987.11977325.

the completion process, which corresponds to the cognition regulation component of metacognitive awareness described earlier.

Numerous studies have indicated a positive correlation between metacognitive awareness and students' mathematical abilities. Students with low metacognitive abilities tend to solve questions unsystematically and rarely re-check the answers[9]. Sabina showed that cognition regulation affects the depth of students' understanding of mathematical concepts[10]. Achsin's study further showed that students with higher metacognitive awareness demonstrated stronger mathematical problem-solving skills compared to those with lower levels of metacognitive awareness[11]. These findings are reinforced by Soinbala and Mulyatna who stated that the active use of metacognitive strategies can improve students' understanding of mathematical concepts[12].

Other research shows that students with high metacognition tend to use better elaboration and information organization strategies when dealing with contextual math problems, while students with low metacognition tend to use superficial memorization strategies[13]. In addition, Lingel et al. found that the monitoring and evaluation components in metacognition are strong predictors of students' mathematical achievement[14]. These findings show that metacognitive awareness has an important contribution in determining the quality of students' mathematical thinking processes.

Although much research has been done on metacognitive awareness and mathematical abilities, most previous studies tend to focus on only one specific mathematical ability rather than examining comprehension and problem-solving together. For example, Sabina examined conceptual understanding and mathematical reasoning, Achsin focused specifically on problem-solving ability, and Soinbala and Mulyatna examined the improvement of concept understanding through metacognitive strategies, while studies that analyze mathematical comprehension ability based on eight indicators in detail together with problem-

[9] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.
[10] Fitri Sabina, 'The Application of Discovery Learning with a Scientific Approach in Improving Conceptual Comprehension and Mathematical Reasoning Skills and Their Impact on Self-Regulated Learning of Junior High School Students', *Madani Journal: Science, Technology, and Humanities* 2, no. 2 (September 2019): 201–15, Https://Doi.Org/10.33753/Madani.V2i2.52.
[11] Much of Achsin, *Problem-Solving Ability in PBL Contextual Approach in Metacognitive Awareness Inventory Review*, 2025.
[12] Halimah Soinbala And Fauzi Mulyatna, 'The Application Of Metacognitive Learning Strategies In Improving Understanding Of Mathematical Concepts', *De Fermat : Journal of Mathematics Education* 2, No. 1 (June 2019): 46–56, Https://Doi.Org/10.36277/Defermat.V2i1.39.
[13] Guangming Wang Et Al., 'Development And Application Of Intelligent Assessment System For Metacognition In Learning Mathematics Among Junior High School Students', *Sustainability* 14, no. 10 (May 2022): 6278, Https://Doi.Org/10.3390/Su14106278.
[14] Klaus Lingel, Jan Lenhart, And Wolfgang Schneider, 'Metacognition In Mathematics: Do Different Metacognitive Monitoring Measures Make A Difference?', *Zdm* 51, no. 4 (August 2019): 587–600, Https://Doi.Org/10.1007/S11858-019-01062-8.

solving ability based on Polya's stages within each metacognitive awareness category remain limited. Therefore, this study offers a scientific contribution through a detailed analysis of students' mathematical comprehension ability based on eight indicators and mathematical problem-solving ability based on Polya's four stages, examined simultaneously across categories of metacognitive awareness, an analytical approach that has not been widely applied in previous research on this topic.

This research was carried out on Social Arithmetic material for grade VIII students of SMPN 1 Ciwaringin, Cirebon. Social Arithmetic material was chosen because it is closely related to daily life situations and requires the ability to understand concepts and solve problems at the same time. In addition, this material is relevant to context-based learning in the Independent Curriculum which emphasizes critical thinking skills and authentic problem-solving. Moreover, Social Arithmetic provides various contextual problems that enable students' metacognitive processes to emerge more clearly during mathematical activities. Based on this description, this study aims to describe students' mathematical comprehension and mathematical problem-solving abilities based on the level of metacognitive awareness in Social Arithmetic material.

Methods

This study employed a qualitative descriptive approach to gain a comprehensive understanding of students' mathematical comprehension and problem-solving abilities in relation to their level of metacognitive awareness on Social Arithmetic material. The data collected include numerical scores, percentages, and mean-based categorization, which were primarily used descriptively to characterize and compare patterns of ability among students. In addition, a one-way ANOVA was conducted for each mathematical ability to test whether the differences observed across metacognitive awareness categories were statistically significant, after the data met the assumptions of normality and homogeneity of variance. The research was conducted at SMPN 1 Ciwaringin, Cirebon, involving 26 eighth-grade students selected through purposive sampling. The participants were selected using two specific criteria: (1) they had received instruction on Social Arithmetic material, so that their responses to the comprehension and problem-solving tests reflected material they had actually studied, and (2) they were willing to complete the questionnaire and both tests and to take part in the member checking process until the research was completed.

Data were collected through questionnaires, tests, and documentation techniques. The questionnaire employed in this study was the Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison, consisting of 32 statements rated on a four-point Likert scale (1 to 4), designed to assess the dimensions of metacognitive knowledge and metacognitive regulation[15]. Item validity of the adapted questionnaire was tested using Pearson product-moment correlation with the 26 students who participated in the study (r-table = 0.388 at $\alpha = 0.05$). The results showed that 29 of the 32 statements were valid (r-count > r-table), while three statements (numbers 26, 27, and 28) were invalid and subsequently excluded, so that the final questionnaire used to measure students' metacognitive awareness consisted of 29 statements with a maximum possible score of 116. Reliability testing using Cronbach's Alpha on the 32-statement version yielded a coefficient of 0.905, indicating a very high level of internal consistency. The mathematical comprehension ability test consists of 16 description questions arranged based on eight indicators of mathematical comprehension according to Izzati and Farizi, with a total maximum score of 47[16]. Meanwhile, the mathematical problem-solving ability test comprised five contextual essay questions developed according to Polya's problem-solving stages, including understanding the problem, devising a plan, carrying out the plan, and reviewing the final solution, with a total maximum score of 54[17]. The score interval for each ability category is presented in Table 2 for mathematical comprehension and Table 4 for mathematical problem-solving. Prior to their use in data collection, both tests were piloted with the same 26 students to examine item validity and reliability. Item validity was tested using Pearson product-moment correlation (r-table = 0.388 at $\alpha = 0.05$); items that did not meet this criterion were excluded from the final scoring, consistent with the treatment applied to the metacognitive awareness questionnaire. Reliability testing using Cronbach's Alpha yielded a coefficient of 0.726 for the mathematical comprehension test and 0.531 for the mathematical problem-solving test, indicating high and moderate reliability, respectively.

All research instruments have gone through a validation process by two mathematics education lecturers and one junior high school mathematics teacher. Validation was carried out on the aspects of indicator suitability, construct, cognitive level, and language readability, using expert judgment rather than a quantitative validity index. The validation results showed that the instrument was feasible to use, with minor revisions related to item wording and clarity based on the validators' feedback.

[15] Schraw And Dennison, 'Assessing Metacognitive Awareness'.
[16] Nurma Izzati And Reo Farizi, *Mathematical Ability: Theory and Examples of Instruments* (Cv. Zenius Publisher, 2025).
[17] B. Czarnocha Et Al., 'Problem Solving And Remedial Mathematics', *Mathematics Teaching-Research Journal* 3, No. 4 (2009): 80–98, Scopus.

The data validity technique is carried out through triangulation methods by comparing the results of questionnaires and tests to obtain data consistency. In addition, member checking was carried out on a limited basis, involving a small number of students purposively selected to represent each of the three metacognitive awareness categories (high, medium, and low). These students were asked to confirm whether the researcher's interpretation of their written answers, particularly the reasoning process reflected in their responses, matched their actual thinking process when completing the tests. The confirmation results were used to support the accuracy of the qualitative interpretation presented in the Result and Discussion section.

Data analysis was carried out in three stages. First, the Metacognitive Awareness Inventory questionnaire score was analyzed to group students into high, medium, and low categories based on the mean and standard deviation norm reference of Azwar[18]. Second, the results of the mathematical comprehension and problem-solving ability test were analyzed based on the stages of Izzati and Farizi. Third, a comparative descriptive analysis was carried out to identify differences in patterns of mathematical ability in each category of metacognitive awareness. Fourth, to examine whether the differences in mathematical comprehension and problem-solving ability across metacognitive awareness categories were statistically significant, a one-way ANOVA was conducted for each ability. Prior to hypothesis testing, the data were tested for normality using the Shapiro-Wilk test (appropriate for a sample size below 50) and for homogeneity of variance using Levene's test.

RESULT

Metacognitive Awareness of Students

Metacognitive awareness *measurements* were carried out on 26 grade VIII students of SMPN 1 Ciwaringin using the *Metacognitive Awareness Inventory* (MAI) questionnaire adapted by Schraw and Dennison[19]. The measurement results showed that the total score of students was in the range of 40 to 101 out of a maximum score of 116, with an average of 72.85 or equivalent to 62.8%. Based on the categorization used in this study, the average is included in the medium category. These results show that most students have already had an early awareness of their own thinking processes and learning activities, especially in recognizing the strategies used when completing math tasks. However, these abilities have not been developed optimally because students have not been consistently able to control and direct their thinking processes during learning.

[18] Saifuddin Azwar, *Penyusunan Skala Psikologi*, 2nd ed. (Yogyakarta: Pustaka Pelajar, 2012).
[19] Schraw and Dennison, 'Assessing Metacognitive Awareness'.

The categorization of students into High, Medium, and Low groups was based on the mean and standard deviation norm reference of Azwar[20]. With a mean of 72.85 and a standard deviation of 18.99 from the 26 students' scores, the category boundaries were set as follows: High for scores above 91.84 (score ≥ 92), Medium for scores from 53.86 to 91.84 (score 54–91), and Low for scores below 53.86 (score ≤ 53).

Table 1. Recapitulation of Student Metacognitive Awareness Categories

MA Categories	List of Students	n	Percentage	Average Score	MA Categories
Height	S-02, S-08, S-14, S-15, S-21, S-23, S-25, S-26	8	30,8%	93,3	Height
Medium	S-01, S-03, S-05, S-06, S-09, S-10, S-11, S-12, S-17, S-18, S-19, S-24	12	46,2%	71,1	Medium
Low	S-04, S-07, S-13, S-16, S-20, S-22	6	23,1%	45,8	Low
Total	-	**26**	**100%**	**72,85**	**Total**

Source: Research data (2026)

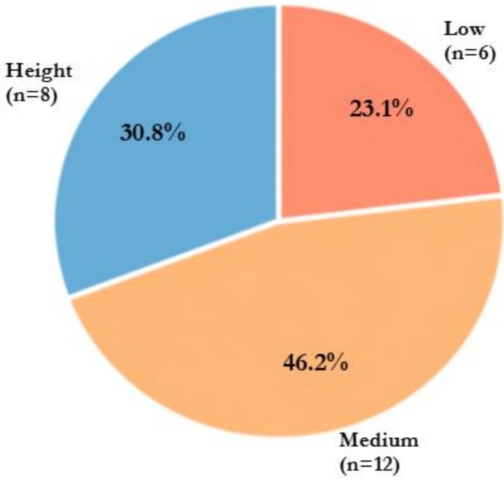

Figure 1. Distribution of Students' Metacognitive Awareness Categories (n=26)

The distribution of the MA category shows that the Medium group dominates with 12 students (46.2%), followed by the High group of 8 students (30.8%), and the Low group of 6 students (23.1%).

Mathematical Comprehension Abilities Reviewed from Metacognitive Awareness

[20] Azwar, *Penyusunan Skala Psikologi*.

The mathematical comprehension (MC) ability test consists of 16 questions that measure eight indicators of comprehension in the context of Social Arithmetic material, with a maximum score of 47. The average MC score obtained was 30.73 (65.4%), being in the Medium category.

Table 2. Distribution of Categories of Students' Mathematical Comprehension Ability

MC Category	Score Interval	n	Percentage	Students	MC Category
Height	39 - 47	6	23,1%	S-08, S-14, S-15, S-23, S-25, S-26	Height
Medium	23 - 38	16	61,5%	-	Medium
Low	0 - 22	4	15,4%	S-04, S-07, S-20, S-22	Low
Total	-	**26**	**100%**	Red = 30.73 (65.4%)	**Total**

Source: Research data (2026)

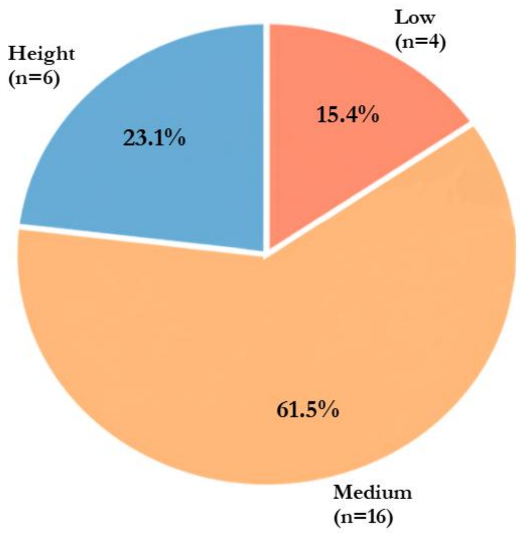

Figure 2. Distribution of Mathematical Comprehension Ability Categories (n=26)

Of the 26 students, only 6 students (23.1%) managed to achieve the High category in mathematical comprehension ability, all of whom came from the MA Tinggi group. A total of 16 students (61.5%) were in the Medium category, and 4 students (15.4%) were in the Low category, all of whom were students from the Low MA group. This distribution pattern shows a consistent directional pattern between metacognitive awareness category and mathematical comprehension ability category, without implying a statistically tested correlation, since this study did not conduct inferential analysis. This pattern is further elaborated through the following per-indicator analysis.

Table 3. Average Mathematical Comprehension Ability Score per MA Category

Cat. AND	n	Average MC Score	MC Value (%)	MC Category	Cat. AND
Height	8	40,38	85,9%	Height	Height
Medium	12	29,50	62,8%	Medium	Medium
Low	6	20,33	43,3%	Low	Low
Total	**26**	**30,73**	**65,4%**	**Medium**	**Total**

Source: Research data (2026)

Table 3 shows a very consistent gradation: the higher the student's MA category, the higher the average mathematical comprehension score. The High MA group reached an average of 40.38 (85.9%), the Medium MA group 29.50 (62.8%), and the Low MA group 20.33 (43.3%).

Mathematical Problem-Solving Abilities Reviewed from Metacognitive Awareness

The mathematical problem-solving ability (MPS) test consists of five description questions based on real-life contexts. Each question contains four problem-solving indicators according to the stages of Izzati and Farizi in an integrative manner, with a maximum score of 54. The average MPS score obtained was 32.35 (59.9%), being in the Medium category[21].

Table 4. Distribution of Students' Mathematical Problem-Solving Skills Categories

MPS Categories	Score Interval	n	Percentage	Students	MPS Categories
Height	43 - 54	6	23,1%	S-02, S-03, S-14, S-15, S-21, S-23	Height
Medium	22 - 42	17	65,4%	-	Medium
Low	0 - 21	3	11,5%	S-04, S-07, S-20	Low
Total	-	**26**	**100%**	Red = 32.35 (59.9%)	**Total**

Source: Research data (2026)

[21] Izzati And Farizi, *Mathematical Ability: Theory and Examples of Instruments*.

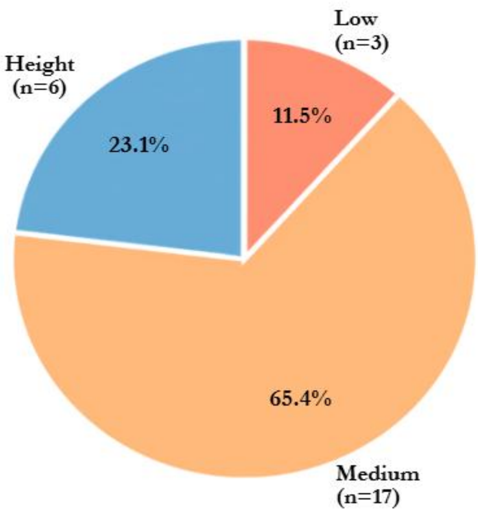

Figure 3. Distribution of Mathematical Problem-Solving Ability Categories (n=26)

Table 5. Average Mathematical Problem-Solving Ability Score per MA Category

Cat. AND	n	Average MPS Score	MPS value (%)	MPS Categories	Cat. AND
Height	8	44,63	82,6%	Height	Height
Medium	12	30,17	55,9%	Medium	Medium
Low	6	20,33	37,7%	Low	Low
Total	**26**	**32,35**	**59,9%**	**Medium**	

Source: Research data (2026)

Recapitulation and Cross-Group Analysis

Table 6. Recapitulation of MC and MPS by Metacognitive Awareness Category

Cat. AND	n	Average MC	MC (%)	Average MPS	MPS (%)
Height	8	40,38	85,9%	44,63	82,6%
Medium	12	29,50	62,8%	30,17	55,9%
Low	6	20,33	43,3%	20,33	37,7%
Total	**26**	**30,73**	**65,4%**	**32,35**	**59,9%**

Source: Research data (2026)

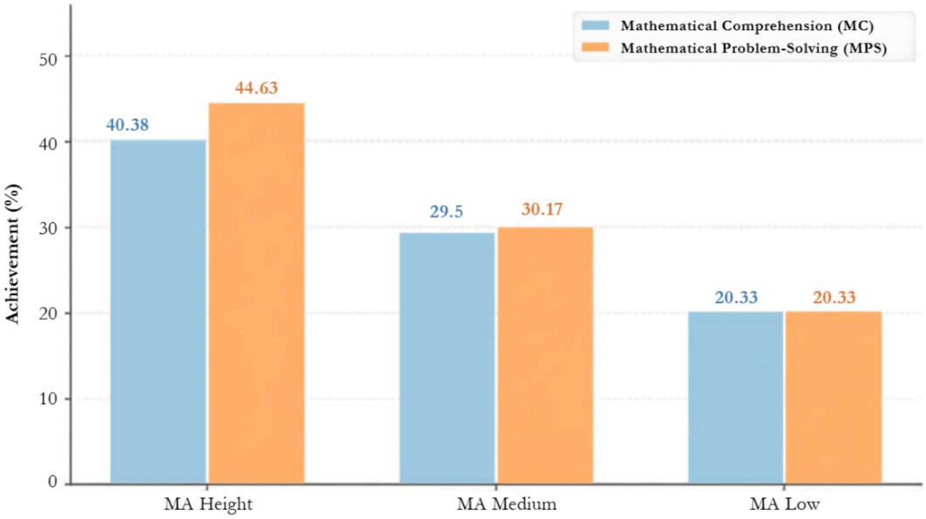

Figure 4. Comparison of Average MC and MPS Scores by Metacognitive Awareness Category

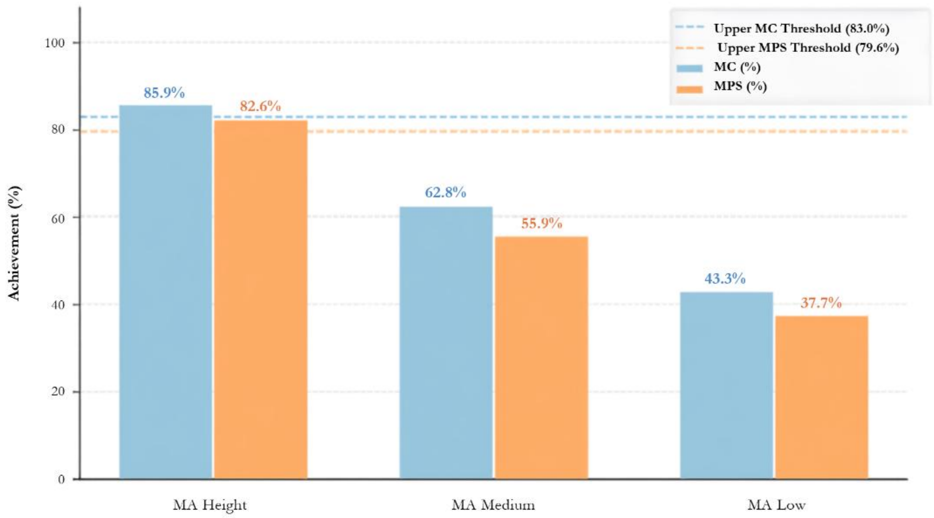

Figure 5. Percentage of MC and MPS Achievement per Metacognitive Awareness Category (%)

Table 6 and Figure 4-5 simultaneously confirm the existence of a very consistent pattern: each increase in the metacognitive awareness category is followed by an equivalent increase in both mathematical abilities measured. There is not a single case where the lower MA group outperforms the higher MA group.

In more detail, the average difference in MC between the High and Medium MA groups reached 10.88 points (23.1 percentage points), while the difference between the Medium and Low MA groups was 9.17 points (19.5

percentage points). For MPS, the difference is larger: 14.46 points between High and Medium MA, and 9.84 points between Medium and Low MA.

It is also worth noting one interesting case: S-03 who is in the Medium MA group managed to reach the High category in MPS (score 43; 79.6%).

Prior to hypothesis testing, the Shapiro-Wilk test confirmed that the data for metacognitive awareness (Sig. = 0.127), mathematical comprehension (Sig. = 0.420), and mathematical problem-solving (Sig. = 0.150) were all normally distributed (Sig. > 0.05). Levene's test also confirmed that the variances of the mathematical comprehension (Sig. = 0.374) and mathematical problem-solving (Sig. = 0.414) data were homogeneous across the three MA categories (Sig. > 0.05). The one-way ANOVA results showed a statistically significant difference in mathematical comprehension ability across the metacognitive awareness categories (Sig. = 0.000, $p < 0.05$), so that H0 was rejected. For mathematical problem-solving ability, the ANOVA result was not statistically significant (Sig. = 0.266, $p > 0.05$), so that H0 failed to be rejected.

DISCUSSION

Metacognitive Awareness of Students

This condition indicates that students still have difficulties in carrying out cognitive regulation independently, such as planning completion strategies, monitoring work steps, and evaluating the results obtained. In mathematics learning, this ability is very important because it is directly related to the accuracy of strategy making and the ability to understand concepts in depth. Schraw and Dennison explain that *metacognitive awareness* includes not only knowledge of thought processes, but also the ability to consciously manage those thought processes[22].

The dominance of the Medium category indicates that most students have begun to develop awareness of their own thought process. However, because this study relies on the aggregate MAI score, it cannot determine in detail which specific component, cognition knowledge or cognition regulation, is comparatively less developed among these students; a more fine-grained sub-scale analysis would be required to establish this. These findings are consistent with the results of Hignasari's research which found that junior high school students in general are still in the stage of metacognition development, where the ability to

[22] Schraw and Dennison.

self-monitor has not been fully internalized[23]. In line with these findings, Sumarna et al also found that junior high school students in grade VIII tend to be at the level of metacognition developed, with planning skills that still need to be explicitly guided[24].

The High MA group (scores 92-101) showed a more active metacognitive profile: they were more likely to plan approaches before working on problems, were more alert to mistakes, and were able to critically evaluate the results of their work. The Low MA group (score 40-55) tends to work impulsively without careful planning and rarely re-examines. This difference in metacognitive orientation is then reflected in the results of each group's mathematical ability test. The difference in metacognitive profiles between students is not solely influenced by intellectual intelligence, but also by learning habits formed through learning experiences that support self-reflection[25].

Mathematical Comprehension Ability

Indicator 1: Restating Concepts Using Your Own Words

The first indicator measures students' ability to restate mathematical concepts using their own language. Students of the MA Higher group are generally able to express concepts with appropriate paraphrasing and accompanied by concrete examples. For example, S-14 writes that profit occurs if the selling price is greater than the purchase price, so that the seller gets more than he spends. The answer shows meaningful understanding because it connects concepts with real transaction logic. Medium MA students tend to use sentences that are closer to formulas, while Low MA students only write formulas without verbal explanation. This pattern is consistent with Khasanah's explanation that students with low metacognitive awareness tend to store knowledge procedurally without building a strong conceptual representation, a tendency she associates with weak declarative knowledge.[26]

[23] L. Virginayoga Hignasari, I. Wayan Lasmawan, and Desak Putu Parmiti, 'Qualitative Study of the Relationship between Metacognition and Self-Assessment on the Mathematical Critical Thinking Skills of Junior High School Students', *Emasains : Journal of Mathematics and Science Education* 15, no. 1 (February 2026): 154–68, Https://Doi.Org/10.59672/Emasains.V15i1.5943.

[24] Maya Sintya Sumarna et al., 'Analysis of Metacognition Ability of Junior High School Students in Pandeglang Regency', *Pedagogy: Journal of Mathematics Education* 10, no. 4 (December 2025): 2068–79, Https://Doi.Org/10.30605/Pedagogy.V10i4.7404.

[25] Hignasari, Lasmawan, and Parmiti, 'Qualitative Study of the Relationship of Metacognition and Self-Assessment on the Mathematical Critical Thinking Skills of Junior High School Students'.

[26] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.

Indicator 2: Classifying Mathematical Objects Based on Specific Properties

The second indicator measures students' ability to group transaction situations based on relevant mathematical properties. The High Court group is able to classify appropriately with clear quantitative reasons. The Medium MA group is mostly able to classify correctly although it does not always include a reason. The Low MA group showed confusion in distinguishing break-even situations from small losses, indicating a conceptual scheme that had not been adequately formed. In line with this, Virgia et al. emphasized that the ability to mathematical classification is highly dependent on the richness of conceptual schemes that students have, which in turn is influenced by how actively students monitor and evaluate their understanding during learning[27].

Indicator 3: Providing Examples and Not Examples of a Concept

The third indicator requires students to provide valid and non-examples of Social Arithmetic concepts. This ability requires a flexible understanding of the essential features of a concept. S-25 of the Higher MA group formulated a non-example by transforming one critical condition from a profit situation to a break-even situation, demonstrating a deep understanding of the boundaries of the concept. Medium MA students are generally able to give examples correctly but have difficulty formulating informative non-examples. Lower MA students make the most mistakes on non-sample items, indicating an inadequate understanding of the distinguishing features of a concept.

Indicator 4: Presenting Concepts in Various Forms of Representation

The fourth indicator measures students' ability to switch concepts from one form of representation to another. Higher MA students are generally able to present concepts in more than one form of representation accurately. Medium MA students are able to perform one representation conversion but struggle to convert to a third form. Lower MA students tend to work only in one direct numerical representation. These findings are in line with Flavell's assertion that multiple representation abilities are closely correlated with the maturity of

[27] Ziva Virgia, Granita Granita, and Zulkifli Zulkifli, 'The Effect of the Application of Metacognitive Strategies on the Ability to Understand Concepts and Mathematical Problems of Junior High School Students', *Journal for Research In Mathematics Learning.* 2, No. 4 (December 2019): 371, Https://Doi.Org/10.24014/Juring.V2i4.8566.

students' metacognitive regulation[28]. The ability to rerepresent concepts is also linked to cognitive flexibility that is actively trained through self-monitoring[29].

Indicator 5: Explaining the Relationship Between Mathematical Concepts

The fifth indicator is the indicator that most demands relational understanding. The S-02 and S-21 of the High MA group were able to identify that the percentage of profit was calculated against the purchase price and explain the logical reasons coherently. Medium MA students are able to calculate the percentage correctly but are not yet able to explain the reasons behind the formula used. Lower MA students experience the most failures on this indicator, both procedurally and conceptually, indicating the absence of a complete relational understanding[30]. Asifa and Tasman added that the ability to build connections between mathematical concepts is highly dependent on how often students reflect on the material studied[31].

Indicators 6, 7, and 8 : Procedures, Algorithm Applications, and Concept Conditions

These three indicators were at the cognitive level C3-C4 and showed the sharpest differences between the MA groups. Higher MA students are able to choose the right procedure, apply it with high accuracy, and identify the conditions for the validity of a mathematical statement. Intermediate MA students are able to carry out familiar procedures, but experience obstacles when the context of the question changes. Lower MA students make the most procedural failures, often choose the wrong formula and do not detect computational errors because they do not do a re-examination. Khasanah calls this pattern a characteristic of students with weak metacognition: they do not have an internal mechanism to detect and correct errors during the process of processing[32]. Zamora et al. also found a similar pattern, where failures at the C3-C4 level were more common in students who did not use self-monitoring metacognitive

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[28] John H. Flavell, 'Metacognition And Cognitive Monitoring: A New Area Of Cognitive–Developmental Inquiry.', *American Psychologist* 34, no. 10 (October 1979): 906–11, Https://Doi.Org/10.1037/0003-066x.34.10.906.

[29] Melissa M. Walwanis And Shelby-Jo Ponto, 'Clarifying Cognitive Flexibility From A Self-Regulatory Perspective', In *Augmented Cognition*, vol. 11580, ed. Dylan D. Schmorrow and Cali M. Fidopiastis, Lecture Notes In Computer Science (Cham: Springer International Publishing, 2019), 631–43, Https://Doi.Org/10.1007/978-3-030-22419-6_45.

[30] Sumarna et al., 'Analysis of Metacognition Ability of Junior High School Students in Pandeglang Regency'.

[31] Putri Asifa And Fridgo Tasman, 'The Core Model For Improving Students Understanding Mathematical Concepts In Class Viii', 2024, 050037, Https://Doi.Org/10.1063/5.0204677.

[32] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.

strategies[33]. This finding indicates that metacognitive awareness plays an important role in supporting students' procedural accuracy and conceptual control when solving mathematical problems at higher cognitive levels.

None of the groups achieved the MC category above their MA category, indicating that metacognitive awareness plays a role as a factor that systemically differentiates the quality of students' mathematical understanding at each level. The consistency of this pattern supports Pintrich's (2002) argument this finding indicates that metacognitive awareness serves an important role as a mediating factor between the learning process and students' learning outcomes.

Mathematical Problem-Solving Ability

Because each problem-solving question was scored holistically rather than with a separate sub-score for each Polya stage, the following analysis of the four stages is based on a qualitative examination of the patterns and errors visible in students' written work, rather than on a numerical score for each stage individually.

Stage 1: Understanding the Problem

The first stage requires students to accurately identify the information known, the questioned, and the relevant conditions in the question. Higher MA students consistently write down known elements and are asked questions before starting to plan for completion, a habit consistent with what the literature describes as the planning component of metacognitive regulation[34]. Medium MA students are generally able to understand the main information, but often miss crucial secondary conditions, such as the existence of a tax component or tiered discounts. Lower MA students tend to jump straight into the calculation procedure without ensuring that all the information about the question has been understood, a pattern that Pathuddin et al also found in students with low metacognition[35]. Surya et al. added that the stage of understanding the problem is the strongest predictor of the overall success of the problem-solving process[36].

[33] Ángela Zamora, José Manuel Suárez, And Diego Ardura, 'Error Detection And Self-Assessment As Mechanisms To Promote Self-Regulation Of Learning Among Secondary Education Students', *The Journal Of Educational Research* 111, no. 2 (March 2018): 175–85, Https://Doi.Org/10.1080/00220671.2016.1225657.

[34] Schraw And Dennison, 'Assessing Metacognitive Awareness'.

[35] Pathuddin Et Al., 'Metacognitive Skills In Low Self-Efficacy Students: A Case Study Of Junior High School Students In The Using Of The Pythagorean Theorem', *Journal On Mathematics Education* 16, no. 3 (August 2025): 783–98, Https://Doi.Org/10.22342/Jme.V16i3.Pp783-798.

[36] Novaria Lailatul Jannah, 'The Application of the Poe (Predict, Observe, Explain) Learning Model to Improve Problem-Solving Skills in Science Subjects in Elementary School', *Modeling: Journal of PGMI's Study Program* 4, No. 1 (March 2017): 132–46, Https://Doi.Org/10.69896/Modeling.V4i1.110.

Stage 2: Plan the Solution

The planning stage requires students to determine the strategy or formula to be used before starting the calculation. This ability is closely related to conditional knowledge in the metacognition knowledge component, which is the ability to know when and why certain strategies are more appropriate. The High MA group is able to identify the most efficient strategy before carrying out the calculations. The Medium Supreme Court group generally immediately writes down the remembered formula without considering its accuracy for the context of the question. The Low MA group most often errs in choosing strategies, tending to use the formula last taught without considering its suitability. Jamitko et al. emphasized that the weakness at this planning stage can be overcome through explicit habituation of the use of heuristic strategies accompanied by metacognitive reflection[37].

Stage 3: Implementing a Problem-Solving Strategy

The execution stage showed the most pronounced differences quantitatively between the three groups. Higher MA students display organized work steps, and the computational errors that occur tend to be detected and corrected immediately, a pattern consistent with what the literature describes as the comprehension monitoring component of metacognitive regulation. The Medium MA group showed diverse execution capabilities: some were able to execute procedures correctly but experienced minor undetected computational errors. The Low Supreme Court group made the most procedural errors in the form of using incorrect formulas, value substitution errors, and fundamental and uncaught computational [38]errors. Mawaddah and Anisah found that the comprehension monitoring component was the strongest predictor of procedural execution accuracy in solving mathematical problems[39].

Stage 4: Interpreting and Re-Examining the Solution Results

The fourth stage is the stage that students most often overlook, but metacognitively it best reflects the maturity of metacognitive awareness. Higher MA students are the only group that consistently performs this stage

[37] Jatmiko Jatmiko, Heri Retnawati, And Arif Rohman, 'Planning Strategy Through Reducing Cognitive Load Of Secondary School Students: Brief Metacognitive Development Analysis', *Edelweiss Applied Science And Technology* 9, no. 4 (April 2025): 1928–41, Https://Doi.Org/10.55214/25768484.V9i4.6429.

[38] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.

[39] Mawaddah And Anisah, *Students' Mathematical Problem-Solving Ability in Mathematics Learning Using the Generative Learning Model in Junior High School.*

meaningfully. S-21 and S-23 consistently add concluding sentences that restate the answer in the context of the question, demonstrating the understanding that mathematical solutions must be contextually meaningful, not just numbers. This behavior is consistent with what the literature describes as the evaluation component in the regulatory dimension of metacognition [40]. Medium MA students do very minimal re-examinations, while Lower MA students almost never do this stage at all. Khasanah emphasized that the inability to re-examine is the most consistent characteristic of students with low metacognitive abilities[41]. Gomez Alfarez added that the habituation of the explicit looking back stage in learning can train the evaluation component of metacognition while improving the accuracy of students' final [42]answers. These findings indicate that the ability to interpret and re-examine solutions is not merely a procedural step, but also reflects students' awareness in controlling and evaluating their own thinking processes during problem solving.

Cross-Group Synthesis

This consistent directional pattern indicates an association between metacognitive awareness and the quality of students' mathematical abilities. As reported in the Result section, the one-way ANOVA confirms that this association is statistically significant for mathematical comprehension ability (Sig. = 0.000), but not for mathematical problem-solving ability (Sig. = 0.266). This distinction matters: while the descriptive pattern is consistent across both abilities, only the differences in comprehension ability can be considered statistically robust in this sample. The pattern observed for problem-solving ability, despite being visually consistent, remains a descriptive tendency that does not reach statistical significance.

Interestingly, the raw score gap between MA categories is descriptively larger for problem-solving than for comprehension (14.46 versus 10.88 points between the High and Medium groups), yet it is the comprehension difference that proved statistically significant, not the problem-solving difference. This apparent contradiction likely reflects greater score variability within each MA category on the problem-solving test; cases such as S-03, whose problem-solving

[40] Schraw And Dennison, 'Assessing Metacognitive Awareness'.

[41] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.

[42] Lilian Gómez Álvarez, María Soledad Sandoval Zúñiga, and Katia Sáez Carrillo, 'Auditory Comprehension in English as L2: Effect of the Explicit Instruction of Metacognitive Strategies for Their Development', *Rla. Journal of Theoretical and Applied Linguistics* 50, No. 1 (2012): 69–93, Https://Doi.Org/10.4067/S0718-48832012000100004.

score did not match their MA category, increase within-group variance and reduce the statistical power available to detect a between-group difference with a sample of 26 students. This finding is somewhat unexpected in light of theoretical work suggesting that problem-solving requires more active self-regulation [43], and that metacognitive regulation has a greater impact on nonroutine mathematical problem solving than on more structured conceptual understanding, as argued by Jacobse and Harskamp[44]. The absence of a statistically significant difference for problem-solving ability in this study does not necessarily contradict this theoretical position; it may instead reflect the influence of other factors not controlled for in this study, or the limited statistical power of a sample of 26 students to detect a true effect on an outcome with greater score variability.

This case shows that although metacognitive awareness has an important role, other factors such as motivation or procedural mastery can also contribute. Herlina et al. call this factor a compensatory mechanism, where students can achieve higher performance than their metacognitive predictions through very strong procedural mastery[45]. Cases such as S-03 are an exception and do not debunk the main findings of this study. More broadly, the consistent pattern found in this study should not be read as showing that metacognitive awareness is the only factor shaping students' mathematical comprehension and problem-solving abilities. Other factors that this study did not measure or control for, such as students' prior mathematical ability, learning motivation, prior learning experience, the quality of classroom instruction received, and procedural knowledge, could also contribute to the differences observed between groups[46]. Because this study used a descriptive design without controlling for these variables, the patterns reported here should be understood as a description of tendencies within this particular group of students, not as isolated evidence that metacognitive awareness alone produces these differences in ability.

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[43] Arbaiti Br Ginting, Rinjani Vemilia, And Zahra Anindya, *Analysis of the Role of Self-Regulation in Overcoming Obstacles to Solving Students' Mathematical Problems in Inverse Matrix Material*, N.D.

[44] Annemieke E. Jacobse And Egbert G. Harskamp, 'Towards Efficient Measurement Of Metacognition In Mathematical Problem Solving', *Metacognition And Learning* 7, no. 2 (August 2012): 133–49, Https://Doi.Org/10.1007/S11409-012-9088-X.

[45] F. M. Yolanda Kase Et Al., 'Factors Influencing Academic Achievement Of Mathematics Education Students', In *Aip Conf. Proc.*, vol. 3046, ed. Happy N. et al., no. 1 (American Institute of Physics Inc., 2024), Scopus, Https://Doi.Org/10.1063/5.0194584.

[46] Durgaprasad Sahoo Et Al., 'Factors Influencing Mathematics Achievement among School Students (2015-2025): A Systematic Review', *International Journal of Learning, Teaching and Educational Research* 25, no. 6 (2026): 706–31, Https://Doi.Org/10.26803/Ijlter.25.6.30.

The findings of this study strengthen and expand the Khasanah study by providing a more detailed analysis[47]. The difference in metacognitive awareness is not only reflected in the final score, but also in the pattern of mastery per indicator and per completion stage. In particular, these findings complement the existing literature by showing that in Social Arithmetic material, the regulatory component of metacognition (especially planning and evaluation) has a more determinative role than the knowledge component of metacognition in distinguishing the quality of students' mathematical abilities.

CONCLUSION

This study succeeded in describing the ability to understand and solve mathematical problems of grade VIII students of SMPN 1 Ciwaringin in Social Arithmetic material based on the level of metacognitive awareness. The main findings of this study are the existence of a consistent and systematic positive trend: the High MA group (n=8) achieved an average of 85.9% mathematical comprehension and 82.6% problem solving (both High); the Medium MA group (n=12) reached 62.8% and 55.9% (both Moderate); The Low MA group (n=6) only reached 43.3% and 37.7% (both Low). The one-way ANOVA confirmed that this trend was statistically significant for mathematical comprehension ability (Sig. = 0.000), while the trend for mathematical problem-solving ability, although descriptively consistent, was not statistically significant (Sig. = 0.266).

Analysis per indicator of mathematical comprehension revealed that differences between groups reflected fundamental differences in the quality of thought processes: the High MA group was able to build a rich conceptual understanding, operate multiple representations, and identify relational relationships between concepts; while the Low MA group is stuck in a superficial procedural understanding. Izzati and Farizi's stage-by-stage analysis of problem-solving abilities showed that the most striking differences occurred at the stages of understanding the problem and re-examining it, the two stages most closely associated with the quality of students' metacognitive regulation based on the patterns observed in this study. These findings have important practical implications for math educators. The development of students' mathematical abilities needs to be accompanied by the development of structured metacognitive awareness, for example through the habit of writing a solution plan before

[47] Khasanah, 'Analysis of Mathematical Problem-Solving Ability of Quitters Students Reviewed from Metacognitive Ability'.

working on the problem, guided reflection after doing it, and class discussions that encourage students to articulate their thinking process.

Further research is suggested to explore metacognition-based learning interventions that can simultaneously improve students' metacognitive awareness and mathematical ability, taking into account moderator variables such as learning motivation, cognitive style, and family socioeconomic background. The use of mixed research design in the next research will also provide a more comprehensive picture of the mechanism of mediating metacognitive awareness on mathematical ability, especially in the context of the implementation of the Independent Curriculum in secondary schools.

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