Metacognitive Ability Assessment Tool (MAAT)

Aarvey Shan Nishantar

PhD-Mathematics, Dharmapuri, Forest Colony, Tajganj, Agra, Uttar Pradesh 282001, India

DOI: https://doi.org/10.47772/IJRISS.2026.101100213

Received: 07 August 2026; Accepted: 14 August 2026; Published: 24 November 2026

ABSTRACT

The Metacognitive Ability Assessment Tool (MAAT) is designed to assess students' metacognitive abilities during mathematical problem solving by focusing on the core components of metacognitive regulation: planning, information managing, monitoring, debugging and evaluating. Through open-ended prompts, the tool elicits students' descriptions of how they analyze problems, monitor their solution processes, and evaluate the effectiveness of the strategies they use. Unlike mathematics assessments that primarily measure content knowledge or problem-solving performance, and unlike Likert-scale instruments that rely on self-reported perceptions, the MAAT captures students' actual metacognitive processes as reflected in their written responses. The results provide valuable information for identifying students' metacognitive strengths and areas for improvement, thereby supporting instructional practices that promote self-regulated learning and effective mathematical problem solving.

Keywords*:* Metacognitive ability, planning, information managing, monitoring, debugging and evaluating

INTRODUCTION

Success in mathematics depends not only on what students know but also on how they think while solving problems. This ability to consciously regulate one's thinking, known as metacognition, enables learners to plan their approach, monitor their progress, and evaluate the effectiveness of their solutions. Flavell (1979) introduced metacognition as a fundamental aspect of cognitive development, while Schraw and Moshman (1995) emphasized that metacognitive knowledge and regulation are essential for effective learning. Moreover, students with strong metacognitive skills are more likely to become self-regulated learners who demonstrate higher levels of academic achievement and problem-solving competence (Zimmerman, 2002).

Recognizing the importance of metacognition, this Metacognitive Ability Assessment Tool was developed to measure how students regulate their thinking during mathematical problem solving. Rather than focusing solely on correct answers, the instrument examines the cognitive processes students use before, during, and after solving a problem through structured open-ended prompts. According to Schraw and Dennison (1994), assessing metacognitive awareness provides meaningful insights into learners' strengths and weaknesses in regulating their thinking. Likewise, Veenman (2013) highlighted that metacognitive assessment is essential for understanding students' learning processes and promoting effective self-regulation, while Dignath and Büttner (2008) found that metacognitive interventions contribute to improved learning outcomes.

This assessment tool is grounded in Flavell's (1979) Theory of Metacognition and specifically evaluates the core metacognitive regulation processes of planning, monitoring, and evaluating. The evidence generated from students' written responses can guide teachers and researchers in designing interventions that strengthen learners' metacognitive abilities and mathematical problem-solving skills. As Zimmerman (2002) explained, students become more successful when they actively regulate their own learning processes. Consequently, integrating metacognitive assessment into mathematics instruction does not only measures students' thinking but also cultivates reflective, strategic, and independent learners prepared for lifelong learning (Schraw & Moshman, 1995; Veenman, 2013).

The Metacognitive Ability Assessment Tool (MAAT) serves as a valuable instrument for understanding how students regulate their thinking during mathematical problem solving. By assessing planning, monitoring, and

evaluating processes, the tool provides meaningful evidence of students' metacognitive development and supports the design of instructional strategies that foster reflective, self-directed, and effective problem solvers.

Presentation of the Metacognitive Ability Assessment Tool

The Metacognitive Ability Assessment Tool (MAAT) was developed to assess students' metacognitive abilities during mathematical problem solving. The development of the tool was guided by Flavell's Theory of Metacognition, which emphasizes learners' awareness and regulation of their cognitive processes through planning, monitoring, and evaluating (Flavell, 1979). Unlike conventional mathematics assessments that primarily measure the accuracy of students' final answers, the MAAT examines how students approach problems, regulate their thinking, and reflect on the effectiveness of their solution strategies.

The MAAT consists of five mathematical problem-solving tasks covering measures of central tendency, measures of variability, standard score (z-score), expected value, and sampling and estimation. Each task requires students to respond to three metacognitive phases: planning, monitoring, and evaluating. In the planning phase, students describe their understanding of the problem, identify relevant information, and explain the strategies they intend to use. The monitoring phase requires students to describe how they check their reasoning, verify computations, and ensure that their solution procedures are correctly applied. The evaluating phase encourages students to reflect on the correctness, completeness, and reasonableness of their final answers. After completing the metacognitive responses, students provide their complete mathematical solutions.

The responses in the MAAT are evaluated using a four-level scoring rubric based on four criteria: planning, monitoring, evaluating, and mathematical solution and/or explanation. Each criterion is rated from 1 (Beginning) to 4 (Excellent), with higher scores indicating stronger evidence of students' metacognitive regulation and mathematical reasoning. The total score obtained from the assessment is interpreted using five levels of metacognitive ability: very high, high, moderate, low, and very low. Through this assessment approach, the MAAT provides a comprehensive measure of students' mathematical problem-solving processes by capturing not only what students solve but also how they think while solving.

The Metacognitive Ability Assessment Tool (MAAT) provides a structured means of assessing students' metacognitive abilities during mathematical problem solving by examining how they plan, monitor, and evaluate their thinking. The complete assessment tool is presented in the succeeding section, beginning with the directions for its administration and accompanied by the MAAT Scoring Rubric, which provides the criteria for evaluating students' metacognitive responses.

DIRECTIONS: Read the problem carefully before answering. Complete each activity by following the three phases of **Metacognitive Strategy Instruction (MSI)**: **Planning, Information Managing, Monitoring, Debugging and Evaluating**.

For each problem:

1. **Planning** – Describe how you intend to solve the problem before performing any calculations.
2. **Information Managing** – Explain how you gather, organize, break down, or structure the mathematical information and data given in the problem to make it easier to process and understand.
3. **Monitoring** – Explain how you monitor or check your thinking and solution process while solving the problem.
4. **Debugging** – Describe what steps you take if you realize you made a mistake, encountered a point of confusion, or need to correct an ineffective approach while working through the solution.
5. **Evaluating** – Reflect on how you determine whether your final answer is correct, complete, and reasonable after solving the problem.
6. After completing your metacognitive responses, **show your complete mathematical solution** and write your **final answer** in the space provided.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue XI November 2026

7. Answer all questions honestly and independently. There are **no right or wrong answers** for the Planning, Monitoring, and Evaluating responses. Your responses will help determine how you think while solving mathematical problems.

Problem 1. ***Measure of Central Tendency***

The Mathematics quiz scores of eight students are: 70, 75, 80, 85, 85, 90, 95, 100. Determine the mean, median and mode.

Planning: Before solving the problem, what information is given? How will you determine the mean, median, and mode of these eight quiz scores?

Write your answer here:

_____

_____

_____

Information Managing: How do you organize the eight quiz scores to make it easier to determine the mean, median, and mode? What mathematical information or arrangements do you use to distinguish how each measure is determined?

Write your answer here:

_____

_____

_____

Monitoring: While finding the mean, how do you check that you added all eight scores correctly and divided by the correct number of observations? While finding the median and mode, how do you verify that the scores remain in order and that you correctly identified the middle value(s) and the value that appears most often?

Write your answer here:

_____

_____

_____

Debugging: If you discover that you have incorrectly added the scores, misplaced a value when arranging them, or misidentified the median or mode, what would you do to identify and correct your mistake? How would you adjust your approach if you encountered difficulty determining any of the three measures?

Write your answer here:

_____

_____

_____

Evaluating: After solving, how did you determine that your mean, median, and mode correctly represent the given quiz scores and that no score was omitted or counted incorrectly?

Write your answer here:

_____

_____

_____

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue XI November 2026

Mathematical Solution (Applying Your Metacognitive Ability): Using your **Planning** and **Information Managing** strategies, organize the given information and solve the problem step by step. Apply your **Monitoring** strategies to check your computations and your **Debugging** strategies to correct any errors encountered. Finally, use your **Evaluating** strategies to verify that your answers are correct and reasonable.

Show your complete mathematical solution below.

Problem 2. Measures of Variability

The daily sales (in thousands of pesos) of a small store for five days are: 12, 15, 17, 18, and 23. Determine the range and the sample variance.

Planning: Before solving the problem, what information is given? What strategy and formulas will you use to determine the range and sample variance, and why are these appropriate for describing the variability of the daily sales?

Write your answer here:

Information Managing: How do you organize the five daily sales values and identify the mathematical information needed to determine the range and sample variance? How do you arrange the values, calculate the mean, and organize the deviations from the mean to make the computation of sample variance easier?

Write your answer here:

Monitoring: How do you monitor your work to ensure that you correctly identified the largest and smallest values, calculated the mean accurately, determined each squared deviation correctly, and computed the sample variance accurately?

Write your answer here:

Debugging: If you discover an error in identifying the highest or lowest sales value, calculating the mean, determining the squared deviations, or applying the sample variance formula, what would you do to locate and correct the error? How would you revise your calculations or approach if you encountered difficulty in any step?

Write your answer here:

Evaluating: After solving the problem, how did you determine that your computed range and sample variance correctly describe the spread of the daily sales and that your calculations are correct?

Write your answer here:

Mathematical Explanation (Applying Your Metacognitive Ability): Using your **Planning** and **Information Managing** strategies, organize the given information and solve the problem step by step. Apply your **Monitoring** strategies to check each computation and your **Debugging** strategies to correct any errors encountered. Finally, use your **Evaluating** strategies to verify that your answers are correct and reasonable.

Write your complete explanation below.

Problem 3. **Standard Score (z-score)**

A student obtained a score of 88 on a Statistics examination. The class mean is 80, and the standard deviation is 4. Determine the student's z-score and interpret its meaning.

Planning: Before solving the problem, what information is given? Which formula will you use to determine the student's z-score, and how will it help you describe the student's performance relative to the class mean?

Write your complete explanation below.

Information Managing: How do you organize the given information, such as the student's score, class mean, and standard deviation, to make it easier to identify the values needed in the z-score formula? How do you arrange these values to ensure that each is used correctly in the computation?

Write your complete explanation below.

Monitoring: While solving the problem, how do you check that you correctly substituted the values into the z-score formula and accurately performed the subtraction and division?

Write your complete explanation below.

Debugging: If you discover that you incorrectly identified or substituted the given values into the z-score formula, or made an error in performing the subtraction or division, what would you do to locate and correct the mistake? How would you adjust your approach if you had difficulty interpreting the computed z-score?

Write your complete explanation below.

Evaluating: After solving the problem, how did you determine that your computed z-score and its interpretation correctly describe the student's performance relative to the class average?

Write your complete explanation below.

Mathematical Solution (Applying Your Metacognitive Ability): Using your **Planning** and **Information Managing** strategies, organize the given information and compute the student's z-score step by step. Apply your **Monitoring** strategies to check each computation and your **Debugging** strategies to correct any errors encountered. Finally, use your **Evaluating** strategies to verify that your answer and its interpretation are correct and reasonable.

Write your complete solution here:

Problem 4. Expected Value

A fair die is rolled once. Let X represent the number appearing on the upper face. Determine the expected value of X.

Planning: Before solving the problem, what are the possible outcomes when a fair die is rolled? How will you use the probabilities of these outcomes to determine the expected value of X?

Write your answer here:

Information Managing: How do you organize the possible outcomes of rolling a fair die and their corresponding probabilities to make it easier to calculate the expected value? How do you arrange these outcomes and probabilities so that each outcome is properly matched with its probability in the computation?

Write your answer here:

Monitoring: While solving the problem, how do you check that every possible outcome from 1 to 6 and its corresponding probability have been included correctly in your computation?

Write your answer here:

Debugging: If you discover that you omitted a possible outcome, assigned an incorrect probability, or made an error when multiplying the outcomes by their corresponding probabilities, what would you do to identify and correct the mistake? How would you revise your approach if your computed expected value seemed unreasonable?

Write your answer here:

Evaluating: After solving the problem, how did you determine that your computed expected value is reasonable for a fair die and that all possible outcomes have been considered correctly?

Write your answer here:

Mathematical Solution (Applying Your Metacognitive Strategy): Using your **Planning** and **Information Managing** strategies, organize the possible outcomes and their corresponding probabilities, then determine the expected value of \(X\) step by step. Apply your **Monitoring** strategies to check that all outcomes and probabilities are correctly considered, and use your **Debugging** strategies to correct any errors encountered. Finally, use your **Evaluating** strategy to verify that your answer is correct and reasonable.

Write your complete solution here:

Problem 5. Sampling and Estimation

A school has 1,200 Senior High School students. A researcher randomly selected 100 students and found that 72 of them prefer using digital learning materials instead of printed materials. Estimate the number of students in the entire school who prefer digital learning materials.

Planning: Before solving the problem, what information is given? How will you use the sample data to estimate the number of students in the entire population, and why is this strategy appropriate?

Write your answer here:

Information Managing: How do you organize the given information, including the population size, sample size, and number of students who prefer digital learning materials, to determine the proportion needed for

estimation? How do you arrange these values to establish the relationship between the sample proportion and the entire school population?

Write your answer here:

Monitoring: While solving the problem, how do you check that you correctly identified the sample size, population size, and the proportion of students who prefer digital learning materials before making your estimate?

Write your answer here:

Debugging: If you discover that you incorrectly identified the population size, sample size, or sample proportion, or made an error when applying the proportion to estimate the population, what would you do to locate and correct the mistake? How would you adjust your approach if your estimated number of students seemed unreasonable?

Write your answer here:

Evaluating: After solving the problem, how did you determine that your estimated number of students is reasonable and that your computation correctly represents the sample results when applied to the entire population?

Write your answer here:

Mathematical Solution (Applying Your Metacognitive Strategy): Using your **Planning** and **Information Managing** strategies, organize the given information and solve the problem step by step. Apply your **Monitoring** strategies to check that each officer position is considered correctly, and use your **Debugging** strategies to correct any errors encountered. Finally, use your **Evaluating** strategy to verify that your answer is correct and complete.

Write your complete solution below.

Metacognitive Assessment Tool (MAAT) Scoring Rubric

Criterion	4 – Excellent	3 - Proficient	2 - Developing	1 – Beginning
Planning	Clearly identifies an appropriate strategy before solving and explains how the strategy will be used to solve the combinatorics or probability problem. Demonstrates a clear understanding of the problem requirements.	Identifies an appropriate strategy before solving with a reasonable explanation, but some details are incomplete or unclear.	Identifies a partially appropriate strategy but provides limited explanation or connection to the problem.	Does not identify an appropriate strategy, provides an unrelated plan, or leaves the response blank.
Information Managing	Clearly identifies, organizes, and represents all relevant information in the problem. Distinguishes given and required information and appropriately selects the mathematical concepts, formulas, or relationships needed to solve the problem.	Identifies and organizes most relevant information and selects appropriate mathematical concepts or formulas, but some details are incomplete or unclear.	Identifies some relevant information but demonstrates difficulty organizing it or connecting it to the appropriate mathematical concepts or formulas.	Fails to identify or organize the relevant information, selects inappropriate mathematical concepts, or leaves the response blank.
Monitoring	Consistently checks the solution process, verifies that the chosen strategy is applied correctly, and identifies and corrects errors while solving.	Checks the solution process and applies the strategy correctly but provides limited evidence of error checking or adjustment.	Shows some attempt to monitor the solution process but rarely checks the strategy or possible errors.	Shows no evidence of monitoring the solution process or checking the accuracy of the work.
Debugging	Clearly identifies errors or difficulties encountered during problem-solving, explains their causes, and appropriately corrects them or adjusts the strategy to arrive at a valid solution.	Identifies and corrects errors or adjusts the strategy appropriately but provides limited explanation of the causes or corrections.	Recognizes some errors or difficulties but demonstrates limited ability to explain or correct them.	Does not recognize or attempt to correct errors, provides an unrelated response, or leaves the response blank.
Evaluating	Clearly evaluates the final answer by checking its correctness, completeness, and reasonableness and provides a valid explanation for the conclusion.	Evaluates the final answer with an appropriate explanation but lacks some details or justification.	Provides a limited evaluation with minimal explanation or justification.	Does not evaluate the answer, provides an irrelevant response, or leaves the response blank.
Mathematical Solution and/or Explanation	Presents a complete, accurate, organized, and logically explained solution using appropriate mathematical concepts and procedures.	Presents a generally correct solution with minor errors in computation or explanation.	Presents a partially correct solution with missing steps, unclear reasoning, or several errors.	Presents an incorrect, incomplete, or missing solution with little or no mathematical reasoning.

Metacognitive Ability Level Interpretation (Using the Raw Score of 30)

Total Score Range	Metacognitive Ability Level	Description
26 – 30	Very High Metacognitive Ability	Demonstrates consistent use of metacognitive strategies by effectively planning the solution, monitoring the problem-solving process, evaluating the answer, and providing a complete mathematical explanation.
20 – 25	High Metacognitive Ability	Demonstrates appropriate use of metacognitive strategies with minor weaknesses in planning, monitoring, evaluating, or explaining the solution.
14 – 19	Moderate Metacognitive Ability	Demonstrates partial use of metacognitive strategies but requires improvement in regulating the problem-solving process.
8 – 13	Low Metacognitive Ability	Demonstrates limited awareness and use of metacognitive strategies during problem solving. Requires support in planning, monitoring, and evaluating solutions.
0 – 7	Very Low Metacognitive Ability	Demonstrates minimal or no evidence of metacognitive regulation during problem solving. Responses show little understanding of how to plan, monitor, or evaluate a solution.

Each of the six criteria in the Metacognitive Assessment Tool (MAAT) such as **planning**, **information managing**, **monitoring**, **debugging**, **planning and mathematical solution/explanation** is rated using a four-point scale, with 4 as the highest score and 1 as the lowest. Thus, the maximum attainable raw score is 24, while the minimum attainable raw score is 6. To establish the score intervals corresponding to the five levels of metacognitive ability, the class interval method is applied. This involves determining the highest and lowest possible scores, computing the score range, calculating the class interval width, and establishing the corresponding score intervals.

1. Identify the Highest and Lowest Possible Scores. Note: Determine the maximum and minimum attainable scores based on the scoring rubric of the MAAT.

2. Compute the range score using the formula:

   Range = Highest Possible Score – Lowest Possible Score

3. Determine the Class Interval Width using the formula:

   Class Interval With = $\frac{Range}{Number\ of\ Levels}$

Note: The MAAT consists of five (5) levels of metacognitive ability: Very High, High, Moderate, Low, and Very Low.

4. Establish the metacognitive ability score intervals.

Metacognitive Ability Level Interpretation (Using Mean Percentage Score)

MPS Range	Metacognitive Ability Level	Description
90 – 100	Very High Metacognitive Ability	Demonstrates consistent use of metacognitive strategies by effectively planning the solution, monitoring the problem-solving process, evaluating the answer, and providing a complete mathematical explanation.
80 – 89	High Metacognitive Ability	Demonstrates appropriate use of metacognitive strategies with minor weaknesses in planning, monitoring, evaluating, or explaining the solution.

70 – 79	Moderate Metacognitive Ability	Demonstrates partial use of metacognitive strategies but requires improvement in regulating the problem-solving process.
60 – 69	Low Metacognitive Ability	Demonstrates limited awareness and use of metacognitive strategies during problem solving. Requires support in planning, monitoring, and evaluating solutions.
Below 60	Very Low Metacognitive Ability	Demonstrates minimal or no evidence of metacognitive regulation during problem solving. Responses show little understanding of how to plan, monitor, or evaluate a solution.

Computing the Mean Percentage Score (MPS)

The metacognitive ability level of the students will be interpreted using the **Mean Percentage Score (MPS)**. The MPS will be computed using the following formula:

$$\textbf{MPS} = \frac{\textit{Mean Score}}{\textit{Highest Possible Score}} \textbf{ x 100\%}$$

where:

- **Mean Score** = average score obtained by the students on the MAAT; and
- **Highest Possible Score** = maximum attainable score on the MAAT based on the scoring rubric.

The computed MPS will then be interpreted using the metacognitive ability levels presented in the table above.

REFERENCES

1. Abari, M. T., & Tyovenda, T. (2021). Effect of metacognition on secondary school students' performance in mathematics in Gwer-East Local Government Area of Benue State. *International Journal of Advances in Engineering and Management, 3*(12), 297–302. https://doi.org/10.35629/5252-0312297302
2. Antonio, R., & Prudente, M. (2021). Effectiveness of metacognitive instruction on students' science learning achievement: A meta-analysis. *International Journal on Studies in Education, 4*(1), 43–54. https://doi.org/10.46328/ijonse.50
3. Desoete, A., & Veenman, M. V. J. (2006). Metacognition, learning, and instruction: Bridging the gap between theory and practice. *Applied Psychology, 55*(3), 321–325. https://doi.org/10.1111/j.1464-0597.2006.00258.x
4. Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students: A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*(3), 231–264. https://doi.org/10.1007/s11409-008-9029-x
5. Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906
6. Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033
7. Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351–371. https://doi.org/10.1007/BF02212307
8. Veenman, M. V. J. (2013). Learning to self-monitor and self-regulate. In H. Bembenutty, T. J. Cleary, & A. Kitsantas (Eds.), *Applications of self-regulated learning across diverse disciplines* (pp. 197–218). Information Age Publishing.
9. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64–70. https://doi.org/10.1207/S15430421TIP4102_2

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue XI November 2026

Permission for the use of MAAT

I, **AARVEY SHAN NISHANTAR, PhD-Mathematics**, from Dharmapuri, Forest Colony, Tajganj, Agra, Uttar Pradesh 282001, India, the developer of the Metacognitive Ability Assessment Tool (MAAT) in Statistics and Probability, hereby grant permission for its free use, reproduction, modification, and adaptation for educational, research, and other non-commercial purposes. Users may modify or adapt the MAAT to suit the objectives and context of their own studies, provided that appropriate acknowledgment is given to the developer. Any commercial use, distribution for profit, or incorporation of the MAAT into proprietary materials or products requires the prior written consent of the developer.