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Analysis of Metacognitive Awareness Levels in the Application of Artificial Intelligence in Students

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Abstract: This study utilized Chat GPT to apply Artificial Intelligence in the learning process. The instrument used was the MAI Jr metacognitive awareness questionnaire, adopted from Sperling et al. (2002). The research population consisted of first-semester students in the 2025/2026 academic year of the Chemistry Education program at the University of Mataram. The sampling method used was saturated sampling; thus, the research sample was taken from the entire predetermined population. The results showed that, in general, the metacognitive awareness possessed by first-semester students in the 2025/2026 academic year of the Chemistry Education program at the University of Mataram was not yet fully optimal. The sub-indicators of metacognitive knowledge that need improvement are procedural knowledge and conditional knowledge, as the percentage in the low and very low categories remains high. Furthermore, in the metacognitive regulation indicator, the aspects that need improvement are comprehension monitoring and evaluation. The comprehension aspect is still dominated by students in the low category, while in the evaluation aspect, the high and low categories have the same percentage, which needs to be improved to reach a higher category.

Keywords: Artificial Intelligence; Chemistry Education; Metacognitive Awareness

Introduction

Artificial Intelligence (AI) is a term that emerged from the concepts of Industrial Society 4.0 and Society 5.0, which emphasize "computer programs, machine learning, hardware and software integrated with software inspired by reverse engineering of neuron patterns that operate in the human brain" (Batubara, 2020). The use of AI has become widespread, particularly in the field of education.

Education is one of the sectors influenced by the development of AI-based technology, especially in chemistry learning. In chemistry education, AI—with its capabilities—can assist in processing large and complex data, as well as provide broader opportunities to develop teaching methods and understanding of chemistry concepts, which are often considered difficult (Taruklimbong & Sihotang, 2023). Other studies have discussed the use of AI to help create more interactive Augmented Reality (AR) learning media. Moreover, AI-based AR development can be tailored to the needs and abilities of each learner (Nurhayati et al., 2024).

Most learners perceive chemistry as a difficult subject to understand. This is because chemistry lessons are filled with abstract concepts. As a result, students' learning activities can be both a cause and an effect of low chemistry achievement. This condition indicates that both the quality of the learning process and learning outcomes in chemistry tend to be low (Sudjana & Wijayanti, 2018). In line with this, research by Namira et al (2014) found that chemistry is often perceived as a boring subject due to the large amount of material requiring memorization of formulas and the need for visualization to aid understanding. This perception tends to produce negative responses toward chemistry learning, ultimately affecting students' metacognitive abilities. Therefore, AI-based technology is needed to help students develop and utilize their metacognitive skills.

Metacognition is the awareness of one's own cognition and the ability to control how to direct, plan, and monitor cognitive activities (Fuldiaratman et al., 2021). Metacognitive knowledge is divided into three aspects: first, declarative knowledge—everything learners know about completing a task; second,

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procedural knowledge—knowledge of how to complete a task, including selecting strategies and the problem-solving process from start to finish; and third, conditional knowledge—knowing when and why to use declarative and procedural knowledge to solve a given problem (Rompayom et al., 2010). According to Sholihah et al., (2016), metacognition is related to two dimensions of thinking: the first is self-awareness of cognition, and the second is self-regulation of cognition—using one's awareness to manage thinking processes. For example, a student's success in completing a task may depend on their awareness of what they know and how they apply it, or in other words, their metacognition. Thus, metacognition plays an important role in regulating and controlling one's cognitive processes in learning and thinking, making learning and thinking more effective and efficient.

The learning process at the university level faces the reality that students have varying levels of knowledge and different learning styles. These characteristics include active students, who know how to learn, and who can apply their knowledge; others may have average intelligence but strive to identify their strengths and weaknesses; and some are passive and do not know how to grasp what is being taught. This means that lecturers face classes with students possessing diverse metacognitive abilities (Young & Fry, 2008). In addition, first-semester students tend to still be adapting to university learning, making their learning characteristics difficult to observe directly. Therefore, it is necessary to measure each metacognitive indicator students possess so that lecturers can identify the most appropriate teaching methods for them.

This study aims to measure and describe each metacognitive awareness indicator of first-semester chemistry education students at the University of Mataram in the 2022 academic year. Through this research, lecturers can select appropriate teaching methods and models based on the predominant metacognitive profiles of students in their classes.

Method

This study employed a quantitative approach, as it utilized numerical data. The research design adopted was descriptive quantitative. Descriptive quantitative research is a type of study used to analyze data by describing or portraying the collected data as they are (Sukmadinata, 2007). The quantitative approach with a descriptive quantitative design in this study aimed to determine the levels of metacognitive awareness profile indicators possessed by first-semester students of the 2025/2026 Chemistry Education Program at the University of Mataram.

The metacognitive awareness data were obtained through the Metacognitive Awareness Inventory Junior (MAI Jr), a standardized questionnaire developed by Sperling et al. (2002). The blueprint for the metacognitive awareness questionnaire is presented in Table 1.

Table 1. Blueprint of the Metacognitive Awareness Questionnaire

Aspect	Sub-Indicators
Metacognitive Knowledge	Declarative Knowledge Procedural Knowledge Conditional Knowledge
Metacognitive Regulation	Planning Information Management Strategies Comprehension Monitoring Debugging Strategies Evaluation

The population of this study consisted of 78 first-semester students of the 2025/2026 Chemistry Education Program at the University of Mataram. The sampling technique used was saturated sampling, which allows all members of the population to be included as samples. This technique was selected due to the relatively small population size (Khairunnisa et al., 2022). The research procedure comprised three main stages: preparation, implementation, and data analysis.

a. Preparation Stage

First, the research population was determined. Subsequently, the metacognitive awareness questionnaire to be distributed to the first-semester Chemistry Education students of the 2025/2026 academic year at the University of Mataram was developed. The instrument was then validated through expert judgment.

b. Implementation Stage

Basic chemistry lessons were conducted for first-year Chemistry Education students in the 2025/2026 academic year, utilizing *ChatGPT* as a supplementary learning tool. After the learning process, metacognitive awareness data were collected using the questionnaire. The responses were then checked against the student list to ensure the accuracy of the research respondents.

c. Data Analysis Stage

The metacognitive awareness questionnaire data from first-semester Chemistry Education students of the University of Mataram (academic year 2025/2026) were analyzed using appropriate descriptive statistical methods. The results were then interpreted using the criteria shown in Table 2.

Table 2. Interpretation Criteria for Metacognitive Awareness

No.	Name	Description
$X \geq \bar{X} + 1\ SBx$	Very Positive / Very High	Able to regularly use metacognitive skills to regulate their own thinking and learning processes; aware of many possible ways of thinking, able to apply them fluently, and reflect on their thinking processes.
$\bar{X} + 1\ SBx > X \geq \bar{X}$	High / Positive	Aware of their own thinking and able to distinguish the stages of input, elaboration, and output of their own thoughts; sometimes uses this model to regulate their thinking and learning processes.
$\bar{X} > X \geq \bar{X} - 1\ SBx$	Negative / Low	Unable to separate what they think from how they think.
$X < \bar{X} - 1\ SBx$	Very Negative / Very Low	Appears to lack awareness of thinking within a process.

Notes:
- $\bar{X}$: Mean score of all students in a class
- SBx : Standard deviation of the total scores of all students in a class
- X : Score obtained by the student

(Mardapi, 2012)

Result and Discussion

After the AI-based learning process using ChatGPT as a learning medium, the first-semester students of the 2025/2026 academic year in the Chemistry Education Program at the University of Mataram showed metacognitive awareness profile scores as illustrated in Figure 1.

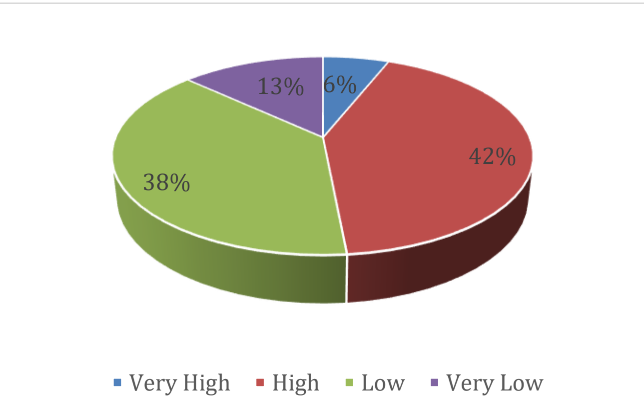

Figure 1. Diagram of Metacognitive Awareness Profile

Based on Figure 1, the metacognitive awareness profile of students who underwent learning with ChatGPT is divided into four categories. Students in the very high category accounted for 6% (5 students), the high category for 42% (33 students), the low category for 38% (30 students), and the very low category for 13% (10 students). Students who possess metacognitive awareness are able to consciously control their own cognitive processes (Iskandar, 2014). Therefore, it can be concluded that most first-semester Chemistry Education students of the 2025/2026 academic year at the University of Mataram who learned using ChatGPT were already able to consciously regulate their own cognitive processes. The metacognitive awareness profile consists of two aspects: metacognitive knowledge and metacognitive regulation.

Metacognitive Knowledge

The percentage distribution of metacognitive knowledge is presented in Figure 2.

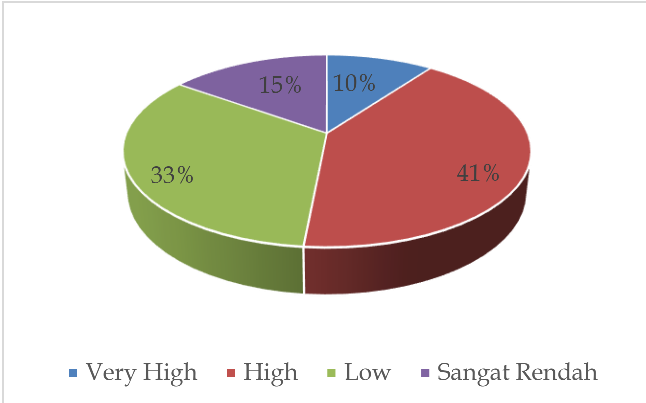

Figure 2. Metacognitive Knowledge Profile

Based on Figure 2, students in the very high category made up 10% (8 students), while the high category comprised 41% (32 students). Meanwhile, the low category accounted for 33% (26 students) and the very low category for 15% (12 students). Possession of metacognitive knowledge leads to meaningful learning—learning that goes beyond mere memorization to higher-order processes such as applying and developing abilities. Students in the very high and high categories are expected to be able to reuse the same learning strategies in different situations and problem contexts (Indarini et al., 2013). Metacognitive knowledge consists of three sub-indicators: declarative knowledge, procedural knowledge, and conditional knowledge. Their percentage distribution is presented in Figure 3.

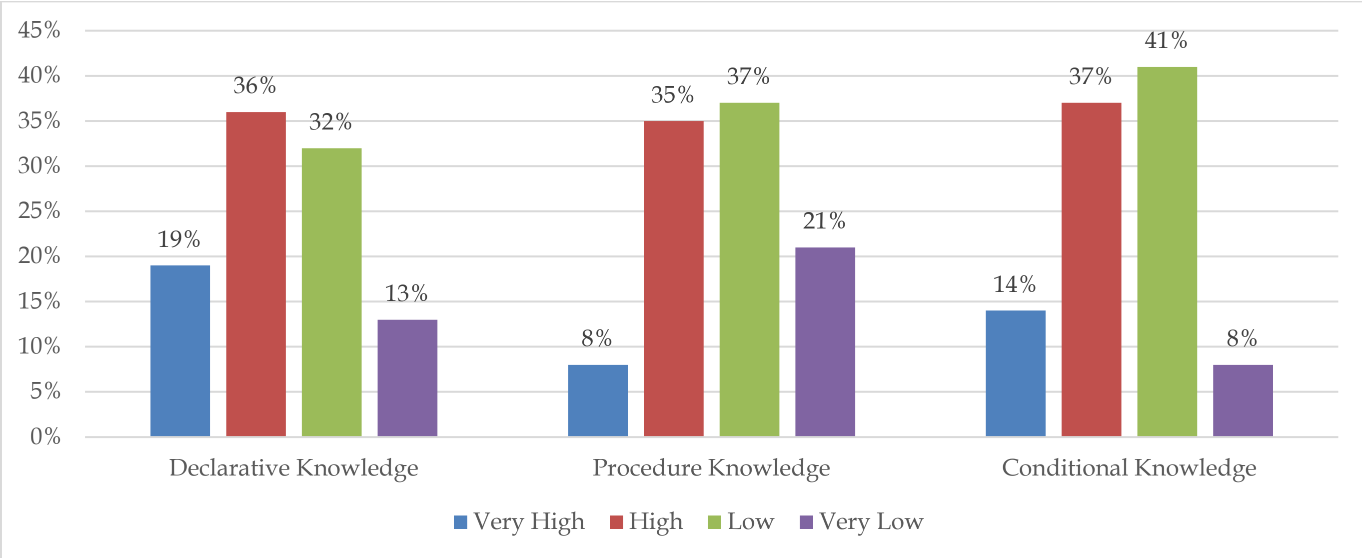

Figure 3. Sub-Indicators of Metacognitive Knowledge

1. Declarative Knowledge

Based on Figure 4, the declarative knowledge sub-indicator has a higher combined percentage for the very high and high categories compared to the other two sub-indicators. The very high category was 19% (15 students) and the high category was 36% (28 students). However, the low category was still substantial at 32% (25 students), and the very low category was 13% (10 students). According to Wardana et al., (2021), learners with strong declarative knowledge can identify their strengths and weaknesses and determine how to address their weaknesses.

2. Procedural Knowledge

Procedural knowledge was in the very high category for 8% (6 students) and high for 35% (27 students). The low category was 37% (29 students) and the very low category was 21% (16 students). Haryanti (2013) states that learners with strong procedural knowledge are able to correctly select and apply the appropriate procedures when solving problems.

3. Conditional Knowledge

Conditional knowledge was in the very high category for 14% (11 students) and high for 37% (29 students). The low category was 41% (32 students) and the very low category was 8% (6 students). As Novita et al (2018) explain, learners with strong conditional knowledge know when and why to use a particular procedure, skill, or strategy, and when not to, as well as the rationale for doing so.

Metacognitive Regulation

The percentage distribution of metacognitive regulation is shown in Figure 4.

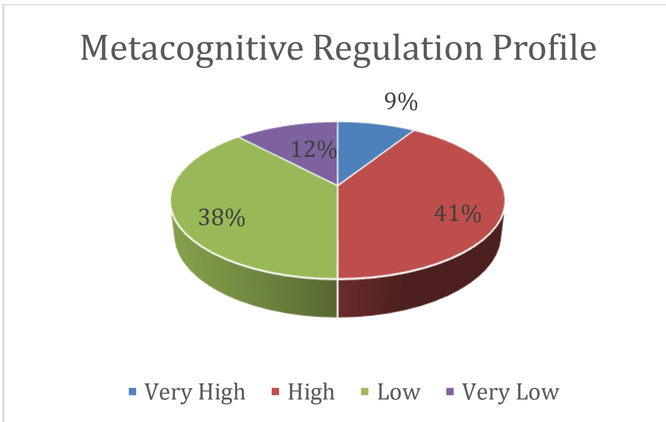

Figure 4. Metacognitive Regulation Profile

Based on Figure 4, students in the very high category were 9% (7 students) and in the high category 41% (32 students). Meanwhile, the low category accounted for 38% (30 students) and the very low category for 12% (9 students). Students in the very high and high categories of metacognitive regulation are considered to possess strong self-regulation skills, enabling them to control, organize, and act more effectively and systematically (Hendrawati, 2022). Metacognitive regulation consists of several sub-indicators, each with different percentage distributions, as shown in Figure 5.

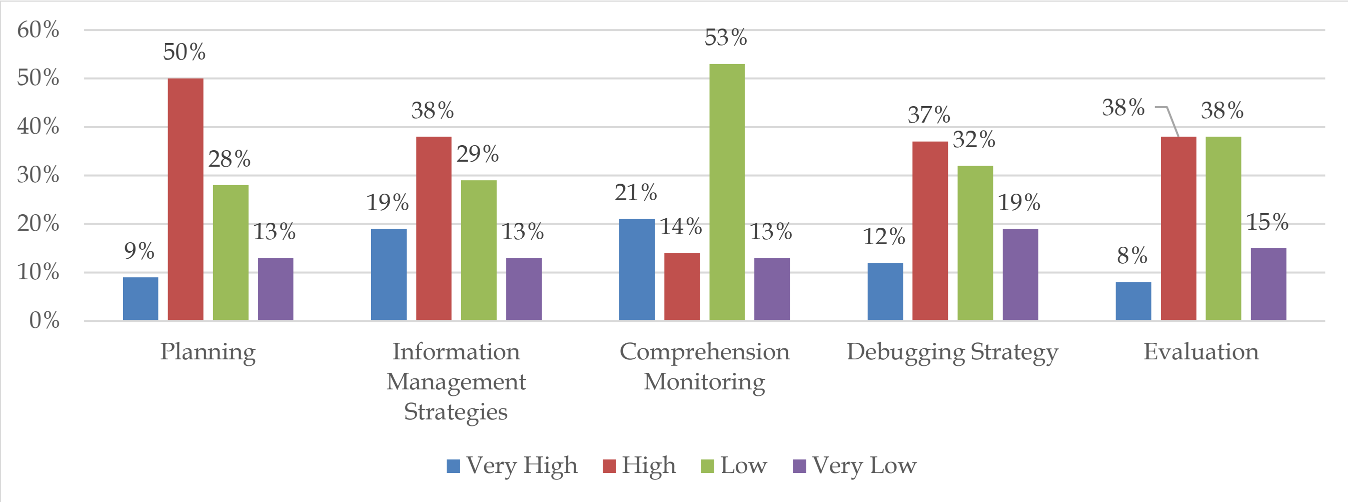

Figure 5. Metacognitive Regulation

1. Planning

Planning was in the very high category for 9% (7 students) and high for 50% (39 students). The low category was 28% (22 students) and the very low category was 13% (10 students). These results show that the combined very high and high categories dominate. According to Sumampouw (2011), planning involves activities such as goal setting and task analysis, which help activate relevant prior knowledge and facilitate the organization and comprehension of learning materials. This suggests that most students were already able to plan activities according to their intended learning goals.

2. Information Management Strategies

Information management strategies were in the very high category for 19% (15 students) and high for 38% (30 students). The low category was 29% (23 students) and the very low category was 13% (10 students). Learners with strong information management strategies focus their attention on important information or problems and develop strategies to facilitate understanding (Paipinan, 2015). This indicates that most students were able to identify important information and formulate strategies to understand it.

3. Comprehension Monitoring

Comprehension monitoring was in the very high category for 21% (16 students) and high for 14% (11 students). The low category was 53% (41 students) and the very low category was 13% (10 students). This shows that the low and very low categories dominate. Learners with good comprehension monitoring are able to track their own learning processes and related activities (Nurchikmah et al., 2022). Therefore, it can be concluded that most students still lacked effective comprehension monitoring skills.

4. Debugging Strategies

Debugging strategies were in the very high category for 12% (9 students) and high for 37% (29 students). The low category was 32% (25 students) and the very low category was 19% (15 students). The data indicate that the combined very high and high percentages are nearly equal to the combined low and very low percentages. Learners with good debugging strategies are able to correct their errors during the learning process (Sugiharto et al., 2020). This suggests that many students had not yet fully optimized their use of debugging strategies to address errors.

5. Evaluation

Evaluation was in the very high category for 8% (6 students) and high for 38% (30 students). The low category was 38% (30 students) and the very low category was 15% (12 students). Learners with strong evaluation skills can assess their own learning outcomes by comparing them to previously set learning goals and applying the material learned to solve problems (Wardana et al., 2020). This suggests that many students had not yet developed the ability to evaluate their own learning effectively.

Conclusion

After implementing Artificial Intelligence-based learning using ChatGPT, it was observed that the overall metacognitive awareness of first-semester students in the 2025/2026 academic year of Chemistry Education at the University of Mataram has not yet reached an optimal level. This is because a portion of the students still fall into the low and very low categories of metacognitive awareness. To achieve a learning process grounded in metacognitive awareness, it is necessary to support it with Artificial Intelligence-based learning over a longer period of time, not only during the duration of this study.

Based on the research conducted within this timeframe, improvements are needed in the sub-indicators of procedural knowledge and conditional knowledge, as the percentage of students in the low and very low categories remains high. Furthermore, within the metacognitive regulation indicators, the aspects that require enhancement are comprehension monitoring and evaluation. The comprehension monitoring aspect is still dominated by students in the low category, while in the evaluation aspect, both the high and low categories have the same percentage, which indicates the need for improvement so that more students can move into higher categories.

Good metacognitive awareness can foster a meaningful learning process for learners.

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Author Contributions
Conceptualized the research idea, analyzed the data, coordinated the implementation of research activities and wrote the article, S. Guided and validated the instruments used in the research and helped formulate the research methodology design and assisted with data analysis, A.A.Z.

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Conflicts of Interest
The authors declare no conflict of interest.

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