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The Impact of Metacognitive Awareness on Retention of Solubility and Solubility Product Equilibrium Concepts

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Abstract
This study aims to describe the level of metacognitive awareness and learning retention regarding the concepts of solubility and solubility product among grade XI students at Senior High School 10 Pontianak, as well as to analyze the correlation between the two variables. The study population consisted of 94 students from classes XI A, XI B, and XI C, with a sample of 57 students selected through simple random sampling from classes XI B and XI C. Data were collected using a Metacognitive Awareness Inventory (MAI) questionnaire to measure metacognitive awareness and an essay test to assess learning retention. Descriptive and inferential statistical techniques were used for data analysis. The results showed that 35% of students demonstrated metacognitive awareness in the "developed" level, while 65% were in the "very well-developed" level. The average learning retention rate for solubility and solubility product concepts was 90.50%, categorized as high. A weak positive and significant correlation (r = 0.280) was found between metacognitive awareness and learning retention, with metacognitive awareness accounting for 7.8% of the variance in learning retention. These findings suggest that while metacognitive awareness influences learning retention to some extent, other factors also play a significant role. This study offers a contribution by specifically exploring the relationship between metacognitive awareness and learning retention on chemistry concepts such as solubility and Ksp concepts at the Senior High School level, a study and subject matter that is rarely explored specifically and simultaneously.

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INTRODUCTION

Learning is a process of reciprocal interaction between teachers and students in the delivery of information to achieve learning objectives. Effective learning is not merely the transfer of knowledge from educators to students but involves activities that enable students to construct their own understanding, such as making meaning and seeking clarity. Meaningful learning that actively involves students in the process can enhance their mastery of concepts (Hasibuan, 2014).

In Indonesia, one of the key challenges in education is the low quality of education and human resources. Learning success serves as an indicator of educational quality, and students' mastery of taught concepts becomes a benchmark for this success. However, learning retention—the ability of students to retain concepts in memory—has received less attention as a quality indicator. Retention reflects the "stickiness" of concepts in students' memories and should complement concept mastery as a measure of learning success. It is therefore essential to analyze not only how well students understand concepts but also how effectively those concepts are retained in their memories (Handayani et al., 2013).

Retention is one of the key indicators of effective learning. According to Gora & Sunarto (2010), the true essence of learning lies in internal processes that include memory, retention, information processing, emotions, and other factors influenced by prior experiences. Chen et al. (2008) emphasized that academic success is closely linked to student retention (Sudirman & Yusnaeni, 2022). Retention reflects the extent to which a learning process is absorbed; the higher a student's retention, the more actively they engage in learning, allowing the material to be stored in long-term memory.

Low student retention can often be attributed to one-directional teaching methods and limited student participation in learning activities (Oliveira, 2017). Effective learning goes beyond listening and observing; it requires active engagement through activities such as reading, asking questions, answering, debating, communicating, discussing, and utilizing available resources. By engaging in such activities, students are more likely to achieve strong learning retention (Juniarsih et al., 2015). This idea aligns with the philosophy of the Chinese thinker Confucius, who stated, "I hear I forget, I see I remember, I do I understand". This philosophy suggests that retention levels improve significantly when students are actively involved in the knowledge construction process (Lubis, 2010). Furthermore, Nurisya et al. (2017) proposed that metacognitive knowledge and skills also play a crucial role in influencing students' retention levels.

Metacognitive awareness plays a crucial role in the learning process, as it involves the ability to monitor and regulate cognitive processes effectively. It consists of two main components: metacognitive knowledge and metacognitive regulation. Metacognitive knowledge is divided into three types: declarative knowledge, which pertains to understanding oneself as a learner, recognizing factors that influence learning and memory, and identifying strategies, skills, and resources required to complete tasks (knowing what to do); procedural knowledge, which involves knowing how to effectively apply strategies to accomplish tasks (knowing how to do something); and conditional knowledge, which refers to understanding when and why specific strategies or procedures should be applied to ensure task completion (knowing when and why to use certain strategies) (Asy'ari et al., 2018). These types of metacognitive knowledge collectively support learners in thinking critically, improving their learning processes, and achieving optimal results during the learning experience (Jaleel, 2016). Additionally, metacognitive awareness enables students to organize and manage their memory effectively, thereby enhancing their ability to retain and apply knowledge (Mitrayani et al., 2021).

The level of metacognitive awareness that students possess significantly affects their learning activities. Students with low metacognitive awareness often exhibit passivity, struggle to manage their learning independently, and achieve subpar academic results (Bahri & Corebima, 2015). In contrast, metacognitive awareness prioritizes control over cognitive processes, empowering students to engage more actively and effectively in their learning (Agustin et al., 2017). Thus, enhancing metacognitive awareness is a critical factor in improving the quality of the learning process. Students who can consciously regulate their cognitive processes are more likely to achieve meaningful learning and better academic outcomes. As such, fostering metacognitive awareness should be a key focus in educational practices to maximize student success (Munir, 2018).

The low learning outcomes among students can be attributed to their low levels of metacognitive awareness. Based on interviews conducted in February 2024 with a chemistry teacher at Senior High School 10 Pontianak, it was found that the teacher was unfamiliar with the concept of metacognitive awareness and lacked knowledge about the instruments used to measure it. These issues have resulted in the absence of follow-up actions to improve the quality of learning that hones students' metacognitive skills, further contributing to their low

metacognitive awareness. Therefore, teachers must pay attention to their students' metacognition. According to Hayati (2016), when students exhibit good metacognitive awareness, their mastery of subject concepts also improves.

Hitipeuw (2009) stated that learning retention is a direct implication of metacognitive skills, meaning retention correlates with metacognition. Metacognitive skills are closely related to social awareness, problem-solving, memory, attention, and self-control (Setiawan & Supiandi, 2019; O'Neil & Brown, 1998). Similarly, Dunlosky & Rawson (2012) revealed that learning achievement and retention improve when students monitor their learning activities and use that monitoring to guide subsequent actions.

Previous research has shown significant relationships between metacognitive awareness and retention. For instance, Nurisya et al. (2016) found a moderate to strong relationship with a correlation coefficient of 0.599. Fauziyah et al. (2013) reported a strong relationship with a correlation coefficient of 0.679, while Wicaksono & Corebima (2015) demonstrated a positive and strong correlation, yielding a coefficient of 0.767. However, there are still few studies that spesifically analyze the relationship between metacognitive awareness and student learning retention on chemistry concepts such as solubility and Ksp concepts at the Senior High School level.

These findings highlight the critical role of metacognition in regulating cognitive processes during learning and thinking, ensuring that these processes are more effective and efficient. This underscores the need for further research into the relationship between metacognitive awareness and retention. Specifically, this study focuses on "The Impact of Metacognitive Awareness on Retention of Solubility and Ksp Concepts." This study aims to investigate the levels of students' metacognitive awareness and learning retention, as well as the relationship between them in the context of solubility and Ksp concepts in Senior High School. Such mapping is crucial as it provides a basis for teachers to design appropriate strategies and methods to develop students' metacognitive awareness, ultimately improving learning outcomes.

METHOD

The type of research used is descriptive and correlational research using a quantitative research approach. The population of this study consisted of 94 grade XI students from Senior High School 10 Pontianak, divided into three classes: XI A, XI B, and XI C. The sample was selected using simple random sampling, resulting in 57 students from classes XI B and XI C.

Data collection in this study used two ways, namely using indirect communication techniques and retention test measurements. The data collection tools used in this study are 1) essay test (5 items) to measure students' chemical retention 2) Metacognitive Awareness Inventory (MAI) questionnaire adopted from MAI by Herlanti (2015) which is an adaptation of MAI by Schraw & Dennison (1994). The MAI questionnaire consists of 45 statements which are divided into two components of metacognitive awareness, namely 16 statements for metacognitive knowledge and 29 statements for metacognitive regulation. The MAI questionnaire used has been tested for validity and reliability by Herlanti (2015). However, in this study, the MAI questionnaire was retested for reliability on grade XI students from Senior High School 10 Pontianak and obtained a Cronbach's alpha of 0,936 which can be seen in Table 1.

The data in this study are from metacognitive knowledge and metacognitive regulation. Metacognitive awareness data is collected through MAI questionnaire which is given after

students do learning activities. Learning retention data was collected by giving an essay test after giving the material. The test questions were given twice. The first test was given after giving the material. Then, one week after the posttest (first test), a retest (delayed test) was conducted with the same question indicators to collect retention data.

Table 1. Reliability test results

Cronbach's Alpha	N of Items
,936	45

The MAI data was then analyzed using a 4-category Likert scale (Strongly Disagree = 1, Disagree = 2, Agree = 4 and Strongly Agree = 5). Furthermore, the score data is then processed into a scale value of 100, with the following calculation.

$$\text{Value} = \frac{\text{Score Obtained}}{\text{Maximum score}} \times 100$$ (Patmawati et al., 2022)

The scores obtained were interpreted based on the level of metacognitive awareness according to Green (2002) in Patmawati et al., (2022) which can be seen in Table 2.

Table 2. Level of metacognitive awareness

Interval	Decision	Interpretation
0-25	Not yet developed	Not yet able to separate what to think, how to think, and does not have a good plan for learning.
26-50	Starting to developed	Able to understand how to think, is aware of his thinking, and can distinguish the stages of input and output elaboration of his thinking process.
51-75	Developed	Able to understand how to think, aware of his thinking, and can distinguish the stages of input and output elaboration of the thinking process, and able to learn independently.
76-100	Very well developed	Able to use metacognitive skills regularly to manage his/her thinking and learning process independently. Able to reflect on their thinking process, and able to self-assess in learning.

The retention score data obtained by students is then processed into a 100 scale value through the following calculation:

$$\text{Value} = \frac{\text{Score Obtained}}{\text{Maximum score}} \times 100$$

The scores obtained were used to calculate student retention using the following formula:

$$Retention = \frac{Re-test}{Post-test} \times 100\%$$ (Sudirman & Yusnaeni, 2022)

To measure the level of retention, the retention value obtained is then categorized based on the retention criteria referring to Sudirman & Yusnaeni (2022) shown in Table 3.

Table 3. Guidelines for categorizing student retention

Category	% Retention
High	≥ 70
Medium	$60 < R < 70$
Low	≤ 60

Source : Sudirman & Yusnaeni (2022)

Furthermore, the data were analyzed inferentially to determine the correlation between variables and hypothesis testing carried out using the Pearson Product Moment correlation test after the prerequisite test of normality test (Kolmogorov-Smirnov Test) and linearity test (Test for Linearity). To calculate the contribution of metacognitive awareness to learning retention, the coefficient of determination formula was used. The correlation test results obtained are interpreted based on the criteria in Table 4.

Table 4. Correlation coefficient interpretation criteria

Interval Coefficient	Level of Relationship
0,00-0,199	Very weak
0,20-0,399	Weak
0,40-0,599	Moderate
0,60-0,799	Strong
0,80-1,000	Very strong

Source : Sugiyono (2016)

RESULTS AND DISCUSSION

Metacognitive Awareness of Students of Grade XI at Senior High School 10 Pontianak

Metacognitive awareness of students of grade XI at Senior High School 10 Pontianak was known by distributing questionnaires to 57 students. The questionnaire consisted of 8 indicators which were translated into 45 statement items and used a Likert scale. In general, the percentage of metacognitive awareness of students of grade XI at Senior High School 10 Pontianak (N = 57) can be seen in Figure 1.

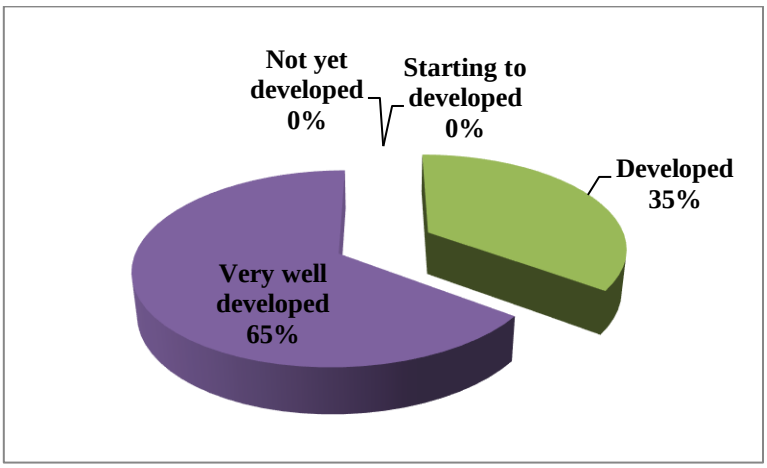

Figure 1. Percentage of metacognitive awareness of students of grade XI at senior high school 10 Pontianak (N=57)

Figure 1 shows that the dominant level of metacognitive awareness (65% of 57 students) of students of grade XI at Senior High School 10 Pontianak is “very well developed”, while the remaining 35% exhibited metacognitive awareness at the “developed” level. According to Green (2002) in Patmawati et al., (2022) this level of awareness is able to use metacognitive skills regularly to regulate their thinking and learning processes independently, can reflect on their thinking processes, and are able to assess themselves in learning. The level of metacognitive awareness according to Green (2002) in Patmawati et al., (2022) can be seen in Table 2.

Student’s very diverse experiences influence the diversity of student’s level of metacognitive awareness and affects their ability to solve problems and learning strategies. Other factors that can also influence include: student activities and participation in organizations, facilities

and infrastructure that support the learning process, daily activities that become habits, interaction with the surrounding environment, and other factors that affect student's learning experiences (Ulfah et al., 2013).

Based on the results of data analysis of metacognitive awareness questionnaire scores for each indicator after being interpreted with Table 2, a description of metacognitive awareness of students in class XI at Senior High School 10 Pontianak can be seen in Table 5.

Table 5. Overview of metacognitive awareness components of students of grade XI at Senior High School 10 Pontianak

Component	Indicators	Percentage of Score (%)	Category
Metacognitive Knowledge	Declarative Knowledge	76,4	Very well developed
	Procedural Knowledge	78,4	Very well developed
	Conditional Knowledge	80,0	Very well developed
Metacognitive Regulation	Planning	79,4	Very well developed
	Information Management Strategy	75,9	Very well developed
	Comprehension Monitoring	79,7	Very well developed
	Debugging Strategy	81,0	Very well developed
	Evaluation	77,6	Very well developed

Table 5 shows that the indicator that has the lowest percentage score is the strategy of managing information, but it is still in the category of very well developed. This indicator relates to how the skills or sequence of strategies that students use to process information more efficiently (e.g., summarizing, developing, organizing, and selectively) (Schraw et al., 1994). The low percentage score on this indicator may be due to students tending to use only superficial learning strategies that are less effective in supporting their metacognitive awareness (Zepeda et al., 2015). In addition, other factors that can also affect students' ability to manage information are high cognitive load and students' information literacy (Sweller, 2020).

Table 5 also shows that the indicator that has the highest percentage score is the debugging strategy. This indicator relates to how the strategies students use to comprehensively correct understanding and errors in the performance that has been done. The existence of a debugging strategy makes a person realize his shortcomings in both understanding and performance that has been done to be evaluated afterwards (Schraw et al., 1994).

The results of the analysis in Table 5 show that each indicator of students' metacognitive awareness is in the category of "very well developed". These findings indicate that students can apply each indicator effectively in their learning activities (Candrawinata et al., 2024).

Learning Retention of Students of Grade XI at Senior High School 10 Pontianak on Solubility and Ksp Concepts

Learning retention of students of grade XI at Senior High School 10 Pontianak on solubility and Ksp concepts is known by giving an essay test after giving solubility and product of solubility material. The test was given twice. The first test was conducted after giving solubility and Ksp concepts. Then, the second test was conducted one week after the first test with the same question indicators. Data on students' learning retention of grade XI at Senior High School 10 Pontianak on the solubility and solubility product concepts obtained an average value of 90.50%. If the average value is interpreted in the benchmark assessment category, then the students' learning retention of grade XI at Senior High School 10

Pontianak on the solubility and Ksp concepts is in the high category. Additionally, 100% of the students achieved a retention value of ≥ 70%, placing them in the high retention category as presented in Table 6. The high learning retention indicates students' success in processing, storing, and retrieving important information related to chemistry concepts in a meaningful way, rather than simply memorizing (Karpicke, 2012).

Table 6. Interpretation of learning retention assessment of solubility and Ksp concepts

Retention (%)	Category	Frequency	Percentage (%)
≥ 70	High	57	100
60 < R < 70	Medium	-	-
≤ 60	Low	-	-

The Correlation Between Metacognitive Awareness and Students' Learning Retention of Grade XI at Senior High School 10 Pontianak on Solubility and Ksp Concepts

Normality and Linearity of Metacognitive Awareness and Learning Retention of Solubility and Ksp Concepts

Data normality was tested using the SPSS 27.0 for Windows program, namely the Kolmogorov-Smirnov test. The results obtained from the data of metacognitive awareness and learning retention of solubility and Ksp concepts are normal. This result is obtained from the significance value of metacognitive awareness and learning retention which is > 0.05, namely 0.073 and 0.086 respectively as presented in Table 7.

Table 7. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Metacognitive Awareness	,112	57	,073	,967	57	,124
Learning Retention	,109	57	,086	,947	57	,014

The linearity of the data was tested using the SPSS 27.0 for Windows program, namely the Test for Linearity test. The results obtained from the metacognitive awareness data and learning retention of solubility and Ksp concepts have a linear relationship. This result is obtained from the significance value (Deviation from Linearity) > 0.05 which is 0.796 as presented in Table 8.

Table 8. Linearity Test Results

ANOVA Table			
			Sig.
Learning Retention * Metacognitive Awareness	Between Groups	(Combined)	,690
		Linearity	,058
		Deviation from Linearity	,796
	Within Groups		
	Total		

Correlation between Metacognitive Awareness and Learning Retention of Solubility and Ksp Concepts

The correlation between metacognitive awareness and learning retention solubility and Ksp concepts is known based on the significance obtained from the calculation of the Pearson Correlation Test using SPSS 27.0 for Windows. The significance obtained as presented in Table 9 is 0.035. The value of 0.035 < 0.05 indicates a positive and significant relationship

between metacognitive awareness and learning retention of solubility and Ksp concepts. This findings is in line with the research by Sudirman & Yusnaeni (2022), which shows that there is a positive and significant relationship between metacognitive awareness and student's learning retention in chemistry concepts.

Table 9. Correlation Test Results between Metacognitive Awareness and Learning Retention (N=57)

Correlations			
		Metacognitive Awareness	Learning Retention
Metacognitive Awareness	Pearson Correlation	1	.280*
	Sig. (2-tailed)		.035
	N	57	57
Learning Retention	Pearson Correlation	.280*	1
	Sig. (2-tailed)	.035	
	N	57	57

*. Correlation is significant at the 0.05 level (2-tailed)

The magnitude of the correlation between metacognitive awareness and learning retention of solubility and Ksp concepts is expressed by the correlation coefficient (r). The correlation coefficient (r) between metacognitive awareness and learning retention of solubility and Ksp concepts as presented in Table 9 is 0.280. The correlation coefficient (r) value of 0.280 is included in the weak relationship level. Therefore, it can be concluded that metacognitive awareness has a positive and weakly categorized relationship with learning retention of solubility and Ksp concepts. This finding is in line with Sudirman & Yusnaeni (2022), who also found a weak correlation with r = 0,366, but deviates from Nurisya et al. (2016) and Wicaksono & Corebima (2015) which found stronger correlations with r values of 0,599 and 0,767, respectively. These findings confirm that even though the relationship is weak, students with better metacognitive awareness tend to be able to retain the information they have learned for a longer period of time. Therefore, teachers still need to integrate metacognitive awareness into their teaching strategies, as metacognition has been shown to enhance student's engagement and retention of chemical concepts (Graham et al., 2019; Arami & Wiyarsi, 2020).

A positive relationship indicates that the variables of metacognitive awareness and learning retention have a relationship or influence on each other and move in the same direction. In general, the positive relationship between the two variables can be seen in Figure 2.

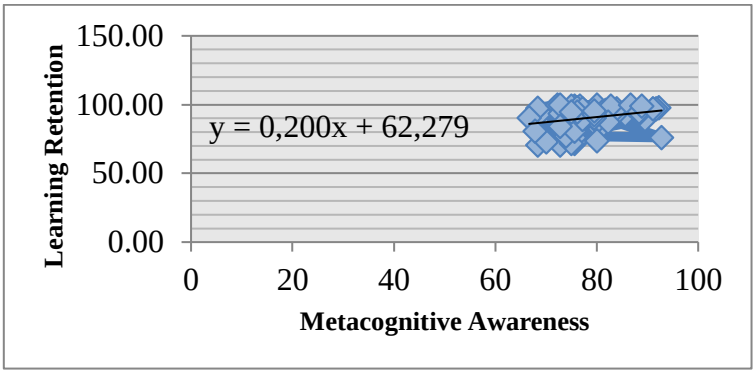

Figure 2. Regression Equation Graph between Metacognitive Awareness and Learning Retention (N = 57)

Based on Figure 2, the regression equation of the two variables is y = 0.200x + 62.279. The equation means that if the value of metacognitive awareness is zero, then student learning

retention is 62.279. So that if the metacognitive awareness variable (X) increases, then learning retention (Y) also increases.

Tabel 10. R Square

Model Summary[b]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	,280[a]	,078	,061	8,914

a. Predictors: (Constant), Metacognitive Awareness
b. Dependent Variable: Learning Retention

Table 10 is the result of data processing of the coefficient of determination of the metacognitive awareness variable (X) with learning retention (Y) using the SPSS 27.0 for Windows program. Based on Table 10, the R Square value is 0.078 which is the magnitude of the coefficient of determination. This shows that there is a contribution of metacognitive awareness of 7.8% to student learning retention in solubility and Ksp concepts, while the remaining 92.2% is caused by other factors. This finding is in line with Halek et al (2022), who stated that the contribution of metacognitive awareness to retention is only 5,5%, but deviates from Sudirman & Yusnaeni (2022), who found a larger contribution of 13,4%.

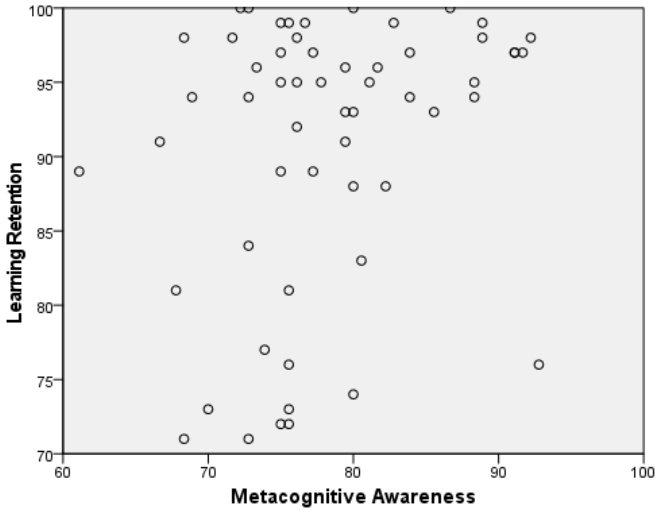

Figure 3. Data Distribution of the Relationship between Metacognitive Awareness and Learning Retention of Solubility and Product of Solubility Concepts of Student in Class XI at Senior High School 10 Pontianak (N = 57)

Figure 3 shows the dominant distribution of data on the relationship between students' metacognitive awareness and learning retention. Based on Figure 3, it shows that the learning retention obtained by students, one of the factors that influence it is metacognitive awareness. So if the average learning retention of solubility and Ksp concepts is obtained with a score ≥ 70, the metacognitive awareness will range from 76-100 with a very well developed category.

Student's learning retention is not entirely influenced by metacognitive awareness. Students with high retention scores, which are around point 100, have metacognitive awareness around point 72. Other data shows that students with learning retention of 76 have high metacognitive awareness of 92. These results show that learning retention can be influenced by other factors. Based on research conducted by Nusantari (2015), there are 5 factors that can affect student retention, including 1) the choice of learning strategy or learning model applied; 2) the characteristics or difficulty level of the material; 3) the academic ability possessed by students; 4) the time of the retention test; 5) internal student factors.

The achievement of metacognitive awareness indicators of students who have the highest retention scores but lower metacognitive awareness on the indicator of information management strategies. Low achievement of information management strategy indicators is not only owned by these students, but the average student of grade XI Senior High School 10 Pontianak has low achievement on these indicator. The indicator relates to how students use strategies and skills in processing the information received efficiently. The low achievement of this indicator among students with high learning retention may be due to the use of superficial learning strategies such as repetition or memorization, rather than deep learning strategies that require complex information processing (Zepeda et al., 2015). In the short term, such strategies may be effective for retention, but they contribute little to metacognitive awareness, particularly in terms of information management (Olop et al., 2024). The development of information management strategy indicators needs to be done to improve student's ability to process information effectively.

In addition, there are students who have high metacognitive awareness but lower learning retention. Learning retention obtained is lower than the results of metacognitive awareness, meaning that student's metacognitive knowledge and regulation are good, but there are other factors that influence their intellectual abilities. According to Fauziyah et al., (2013), intellectual ability plays a big role in the high and low learning achievement, especially in learning that requires a lot of thinking, such as science. There are other factors that can also influence student learning retention, namely the selection of learning strategies or models applied in the learning process. Based on the results of research by Nisa et al, (2024), it was found that students had high retention rates and the ability to remember concepts came from the play activities that were implemented, enabling students to build their own concepts after the learning process through educational chemistry games.

The results of research by Sudirman & Yusnaeni (2022) show that there is a positive and significant relationship between metacognitive awareness and student learning retention. This shows that metacognitive awareness has an important role in the learning process because it has a positive direct relationship with learning retention, meaning that the higher the metacognitive awareness, the better the student's learning retention. The relationship between metacognitive awareness and learning retention has been explained by Howard (2004) that metacognitive abilities play an important role in cognitive activities which include understanding, communication, attention, memory, and problem-solving. Nemati (2009) also states that how well information is remembered is not from how long a person stores the information, but depends on the nature and cognitive processes used in processing the information.

CONCLUSION

The conclusions of this study are as follows: Metacognitive awareness of grade XI students at Senior High School 10 Pontianak regarding solubility and Ksp concepts showed that out of 57 students, 20 students (35%) exhibited metacognitive awareness at the "developed" level, while 37 students (65%) demonstrated metacognitive awareness at the "very well developed" level. Learning retention of grade XI students at Senior High School 10 Pontianak regarding solubility and Ksp concepts was categorized as high, with an average retention rate of 90.50%. Additionally, 100% of the students achieved a retention value of $\geq$ 70%, placing them in the high retention category. There was a positive and significant relationship between metacognitive awareness and learning retention among grade XI students at Senior High School 10 Pontianak on the topics of solubility and Ksp concepts. The correlation coefficient was 0.280, which falls within the weak category. The coefficient of determination was 7.8%, indicating that 7.8% of the variation in students' learning retention was influenced by their

metacognitive awareness. These findings indicate that metacognitive awareness contributes positively to student's learning retention, so it is necessary to integrate the development of metacognitive awareness into chemistry learning strategies.

RECOMMENDATIONS

Considering the research result, it's still need to conduct further research with a larger and more diverse sample to strengthen the findings on the relationship between metacognitive awareness and learning retention. Other factors that may influence the relationship between metacognitive awareness and learning retention need to be explored. Effective learning strategies for improving metacognitive awareness and learning retention need to be developed.

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