



The Influence of Metacognitive Awareness, Learning Independence, and Self-Regulation on Biology Learning Outcomes Students of Senior High School

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Abstract: This study aims to analyze the influence of metacognitive awareness, learning independence, and self-regulation on the biology learning outcomes of Grade XI students at state high schools (SMA Negeri) in Polewali Mandar Regency. The study employs a quantitative approach with an *ex post facto* design. The population consisted of 1,524 students, from which a sample of 228 students was selected using purposive sampling. Data were collected via Likert-scale questionnaires and multiple-choice tests, then analyzed using multiple linear regression. Simple regression analysis results indicate that metacognitive awareness significantly influences biology learning outcomes (significance value $0.000 < 0.05$) with a contribution of 42.9%; learning independence significantly influences biology learning outcomes (significance value $0.000 < 0.05$) with a contribution of 37.7%; and self-regulation significantly influences biology learning outcomes (significance value $0.000 < 0.05$) with a contribution of 27.9%. Simultaneously, these three variables have a positive and significant effect on biology learning outcomes (significance value $0.000 < 0.05$) with a contribution of 55.1%. Based on effective contribution, metacognitive awareness provided the largest contribution (26.2%), followed by learning independence (16.3%) and self-regulation (12.5%). These findings indicate that enhancing metacognitive awareness, learning independence, and self-regulation is crucial for improving students' biology learning outcomes, even though the current levels of these variables remain in the moderate category.

Keywords: Biology learning outcomes; Learning independence; Metacognitive awareness; Self-regulation

Introduction

Biology learning is a necessary knowledge for students at every level of education. Biology not only studies facts, concepts, and principles about living things and their environment, but also requires students to be able to think critically, analyze natural phenomena, solve problems, and make decisions based on scientific evidence. Therefore, the success of biology learning is determined not only by students' cognitive abilities, but also by their ability to manage the learning process effectively (Ihsan et al., 2024). The complexity of the material requires students to be aware of their own

thinking processes, known as metacognitive awareness. Furthermore, learning independence is also a crucial factor in biology learning. The broad scope of biology material and the rapid development of science require students not to rely solely on information provided by teachers but also to actively seek and utilize various learning resources. Furthermore, self-regulation is equally important in supporting the success of biology learning. Regulation refers to students' ability to organize, control, and evaluate their learning behavior to achieve predetermined goals. Therefore, these three aspects are interrelated in supporting the success of biology learning.

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One indicator of the success of the educational process in schools is student learning outcomes. Learning outcomes are not only influenced by external factors such as teacher teaching methods and infrastructure, but also by internal factors originating from within the students themselves. Therefore, it is important to examine internal factors such as metacognitive awareness, learning independence, and self-regulation, which play a role in improving student learning outcomes, particularly at the high school level. Theoretically, metacognitive awareness, learning independence, and self-regulation are three psychological aspects closely related to the learning process. Metacognitive awareness enables students to understand what they know and don't know, as well as to plan, monitor, and evaluate themselves. Metacognitive activity occurs when students consciously adjust and manage their thinking strategies when solving problems and considering goals (Agrawal et al., 2025; Ihsan et al., 2024; Fridman et al., 2020; Klein et al., 2025). Metacognitive awareness can make students more systematic in their thinking and help them identify errors during the learning process (Jaleel & Premachandran, 2016; Stanton et al., 2015; Mustapha et al., 2024). The better a person's metacognition, the better their learning outcomes. A person with good metacognition is able to align knowledge with their skills. This has an impact on the learning outcomes obtained (Swarnadwi et al. 2021).

In addition to metacognitive abilities, student learning independence is an important factor that must be considered to achieve good learning outcomes. Learning independence is defined as a learning process that occurs within oneself, and in an effort to fulfill one's learning needs, a person is required to be active individually and not dependent on others (Dahal & Bhat, 2023; Yu, 2024). Learning independence is considered to have a significant influence on learning outcomes. This statement is based on research written by Susilo et al. (2021) and Amelia & Annisa (2023), which identified the influence of learning independence on learning outcomes. Meanwhile, research written by Fitriana et al. (2015) showed a positive and significant influence of learning independence on learning outcomes.

Another aspect to consider for successful learning is self-regulation. The term "self" refers to the individual, while "regulation" denotes management or control; thus, self-regulation represents an individual's effort to manage themselves across various aspects of life (Fitriya & Lukmawati, 2016; Ningrum et al., 2020). It also encompasses the effort to manage one's thoughts, feelings, and behaviors through monitoring and self-evaluation, ensuring alignment with personal goals, expectations, and desired achievements. Students with

high levels of self-regulation are capable of creating study schedules, maintaining concentration during lessons, and overcoming lethargy or learning distractions (Korb, 2012). A student's attitude toward accepting responsibility shows a strong positive correlation with academic achievement, particularly regarding goal-setting and planning strategies (Oparaji & Ugwu, 2019; Becker, 2011). This aligns with research indicating that students with superior self-regulation skills tend to study more effectively and achieve better academic results (Lai & Hwang, 2016). In the school learning environment, students are required to actively and independently manage themselves and their behavior, as this is crucial for enhancing the effectiveness of learning outcomes.

Learning outcomes are essentially changes in behavior as a result of learning in a broader sense covering the cognitive, affective, and psychomotor domains (Sudjana, 2009). According to Benjamin S. Bloom (cited in Nafiati (2021), there are six types of behavior within the cognitive domain: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Low student learning outcomes can stem from several factors; one such factor is a lack of self-control across various aspects of life—specifically self-regulation—manifesting as a deficiency in self-observation skills and the influence of environmental factors. Self-observation represents a student's effort to manage their learning outcomes, a capability influenced by personal factors. Meanwhile, from an environmental perspective, learning through the observation of others and personal experience significantly impacts the process of comprehending subject matter (Hastuti et al., 2019). To support the learning process, individuals strive to create a conducive environment. Thus, self-observation, personal factors, and the student's environment are interconnected and can foster a sense of independence, enabling students to achieve their learning goals.

This is in line with research conducted by Hastuti et al. (2019) and Assagaf (2016), which showed that learning independence and self-regulation have a positive influence on learning outcomes, both directly and indirectly. Furthermore, Ihsan et al. (2024) has also proven that metacognitive awareness has a positive and significant influence on learning outcomes. However, no research has yet conducted a joint study of these three variables. Most studies only examine two or one of the three variables separately. Therefore, this research contributes to enriching educational theory through a more integrative approach and provides a more comprehensive conceptual model in efforts to understand and improve high school students' biology learning outcomes.

Based on observations and interviews conducted by the researcher with the biology teacher, it was found that students' abilities to grasp the subject matter vary considerably. While some students demonstrate positive learning attitudes such as actively asking questions, seeking additional references, and completing assignments independently others remain passive, studying only when assigned tasks or as exams approach. The teacher also noted that some students lack the ability to evaluate their own understanding; when encountering difficulties, they tend to wait for the teacher to provide an explanation. This situation hinders the learning process, thereby impacting student learning outcomes. Evidence of this impact is seen in the fact that some Grade XI students have yet to meet the established Minimum Mastery Criteria (KKM).

Based on the observations that have been made, it was found that there are still students who are embarrassed to ask questions, embarrassed to express opinions because they lack confidence and are not sure of their abilities, there is still a lack of learning independence to get good learning results, here students tend to be passive in seeking additional information in understanding learning and there are still students who study before exams and do assignments from teachers before submitting assignments, do not yet have self-regulation skills related to metacognition.

Based on the preceding discussion, it is evident that the quality of education is not determined by a single factor but rather by a number of mutually influencing variables. This realization prompted the author to conduct a study to examine the direct influence of each variable, both individually and simultaneously. Consequently, the researcher intends to carry out a study titled "The Influence of Metacognitive Awareness, Learning Independence, and Self-Regulation on Biology Learning Outcomes of Grade XI Students at State Senior High Schools in Polewali Mandar Regency."

Method

Research Type and Research Design

This research is a quantitative ex post facto study with a multiple correlational approach. The aim of this study was to determine the effect of several independent variables on the dependent variable without any treatment. This research was conducted at a public high school in Polewali Mandar Regency in the even semester of the 2025/2026 academic year, May 2026.

The sample of this study was taken from the population of eleventh-grade students of senior high schools in biology classes in Polewali Mandar Regency. The sampling technique used was purposive sampling based on certain considerations or criteria. The criteria set in this study were high schools in Polewali Mandar

Regency with the largest number of students. The population consisted of 12 schools with different numbers of students. Then, four schools were selected, namely SMA Negeri 2 Polewali, SMA Negeri 3 Polewali, SMA Negeri 1 Wonomulyo, and SMA Negeri 1 Campalagian, located in Polewali Mandar Regency. To determine the number of samples, the researcher was guided by Arikunto (2010) that if the population is less than 100 subjects, it is better to take all of them so that the research becomes a population study. Furthermore, if the subject is large, it can be taken between 15, 20, 25% or more depending on the researcher's ability in terms of time, energy, funds, and the narrowness of the area. Because this concerns the amount of data and the size of the risk borne by the researcher. So, the sample in this study was taken as much as 15% of the total population to be studied, namely $15\% \times 1,524$, so that 228 samples were obtained.

The data collection technique was carried out by providing instruments to students who were the research sample. The data collection technique used in this study was a biology student learning outcome test and three types of questionnaires, namely a metacognitive awareness questionnaire using a Likert scale to measure the influence of student metacognition on learning outcomes, a learning independence questionnaire using a Likert scale to measure the influence of student learning independence on learning outcomes and a self-regulation questionnaire using a Likert scale. Before being used in the study, the research instrument was first tested for validity using the Person Product Moment correlation and its reliability was carried out using the Cronbach's Alpha coefficient to ensure the consistency of the instrument.

The research data were analyzed using descriptive and inferential statistical analysis with the help of IBM SPSS Statistics. The prerequisite analysis tests were carried out through normality tests using Komogrov-Smirnov, linearity tests, multicollinearity tests, heteroscedasticity tests, and hypothesis tests using simple linear regression and multiple linear regression to determine the effect of metacognitive awareness, learning independence, and self-regulation on students' biology learning outcomes. The complete procedure of this research, from the implementation stage to the end, can be seen in Figure 1.

Table 1. Number of research samples each school

School name	Number of students	Sample
SMAN 1 Campalagian	196	61
SMAN 1 Wonomulyo	218	68
SMAN 2 Polewali	166	52
SMAN 3 Polewali	145	47

The population in this study was all eleventh-grade students of public senior high schools in Polewali Mandar Regency for the 2025/2026 academic year, while the sample used was taken from the student population. Details of the population and sample are shown in the Table 1.

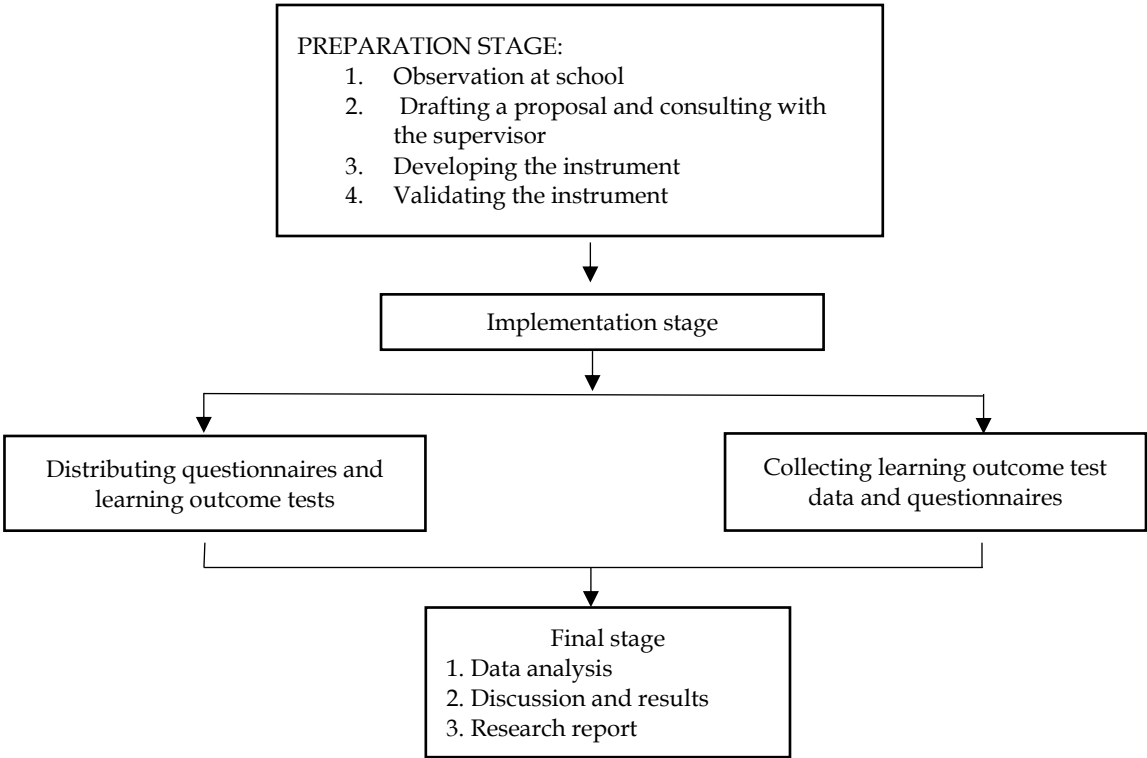


Figure 1. Research design

Result and Discussion

The results of the descriptive statistical analysis describe each research variable, namely metacognitive awareness (X1), learning independence (X2), and self-regulation (X3), with the learning outcomes of 11th-grade biology students (Y) at a public high school in Polewali Mandar Regency, with a sample size of 228. Data obtained from students filling out tickets consisted of 25 statements and a learning outcome test with 25

questions. The following table presents the descriptive analysis of the four research variables.

Descriptive statistical analysis aims to describe the characteristics of metacognitive awareness, learning independence, self-regulation, and biology learning outcomes in students. The results of the descriptive analysis include the number of samples, mean, median, maximum value, minimum value, and standard deviation. The data from the descriptive analysis of metacognitive awareness are presented in Table 2.

Table 2. Descriptive analysis of metacognitive awareness (X1), learning independence (X2), and self-regulation (X3) and biology learning outcomes (Y)

Variables	Sample	Mean	Median	Max	Min	Std. Dev
Metacognitive Awareness	228	68.11	69	90	41	7.617
Learning independence	228	72.04	72	94	57	6.346
self-regulation	228	72.60	72	90	50	6.378
learning outcomes	228	67.69	69	85	50	6.389

Descriptive Analysis of Metacognitive Awareness

Metacognitive awareness refers to the recognition of one's cognitive processes and is often associated with improved learning outcomes and effective problem-solving skills. Metacognitive awareness can influence self-concept, decision-making processes, and overall psychological well-being. Students with strong metacognitive awareness are more likely to become

independent learners. They are able to regulate their learning process by planning, monitoring, and evaluating themselves. Metacognitive activity occurs when students consciously adjust and manage their thinking strategies when solving problems and considering goals (Agrawal et al., 2025; Ihsan et al., 2024; Fridman et al., 2020).

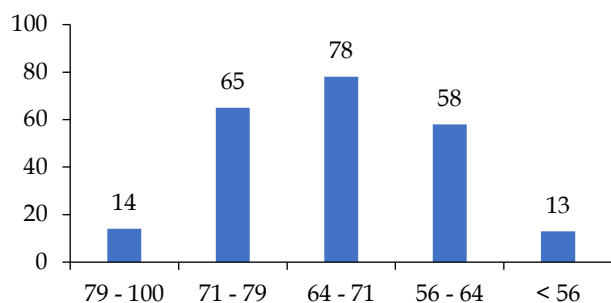


Figure 2. Diagram of metacognitive awareness

Based on Figure 2, it shows that metacognitive awareness is in the moderate category with a frequency of 78 students with a percentage of 34.2%. This result indicates that some students of Class XI MIPA of State Senior High Schools in Polewali Mandar Regency who were respondents have sufficient metacognitive awareness. The moderate category obtained shows that students have been able to use several metacognitive strategies in biology learning, such as planning how to study and re-checking understanding of the material, but have not consistently applied these strategies in all learning activities.

This is in line with research conducted by Ihsan et al. (2024), which states that students with high metacognitive awareness are able to recognize their strengths and weaknesses and are able to evaluate and revise their learning process. This is in line with research by Zamsir et al. (2021), where metacognitive awareness is in the moderate category with a percentage of 54.5%. This indicates that students with a moderate perception of metacognitive awareness already have good metacognitive knowledge and metacognitive regulation.

Ihsan et al. (2024) demonstrated that students with strong metacognitive skills are more likely to become independent learners. Metacognitive activity occurs when students consciously adjust and manage their thinking strategies when solving problems and considering goals. This means that the higher a student's metacognitive awareness, the higher their conceptual mastery.

Descriptive Analysis of Metacognitive Awareness

Learning independence is the willingness and ability of individuals to learn on their own initiative, with or without the assistance of others in determining learning objectives, learning methods, and evaluating learning outcomes. Learning independence is a factor that influences student learning outcomes. Students with high levels of learning independence will strive to complete tasks assigned by teachers, while those with low levels of learning independence will depend on others (Nurlia et al., 2017).

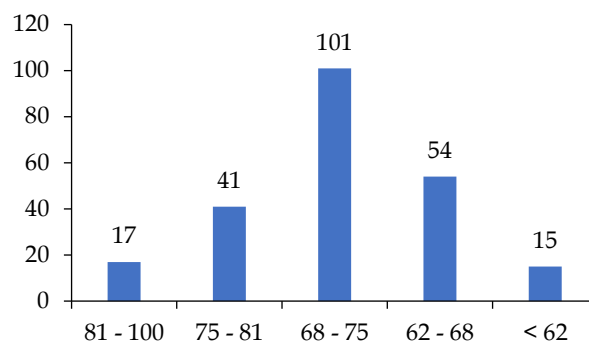


Figure 3. Diagram of learning independence

Based on Figure 3, it can be seen that learning independence is in the moderate category with a frequency of 101 students or a percentage of 44.3%. These results indicate that some of the Grade XI MIPA students at SMA Negeri Polewali, Mandar Regency who were respondents have good learning independence. Good learning independence usually has good self-confidence, is able to take initiative in learning, is disciplined in managing time, and is responsible for their academic assignments. Conversely, students with moderate learning independence tend to still need direction and motivation from teachers in completing learning assignments.

In line with research conducted by Sadykova et al. (2024), it shows that student learning independence is in the moderate category, namely 59 students with a percentage of 58%. This is also in line with previous research presented by Nurlia et al. (2017) who stated that students who have high learning independence will try to complete all exercises or assignments given by the teacher to the best of their abilities. Therefore, student learning independence is very important for teachers to pay attention to and improve. These results support Knowles' opinion that learning independence is an individual's ability to take the initiative in diagnosing learning needs, determining learning goals, selecting learning resources, and evaluating learning outcomes achieved.

Descriptive Analysis of Self-Regulation

Self-regulation views learning as an activity undertaken by students for themselves, actively seeking information about the lessons they learn, rather than as a result of learning experiences. Self-regulation can be viewed from personal perspectives, learning behaviors, and the learning environment. Students with strong self-regulation will naturally develop learning plans, monitor each step of their learning with confidence and responsibility, and evaluate their learning outcomes (Ningrum et al., 2020).

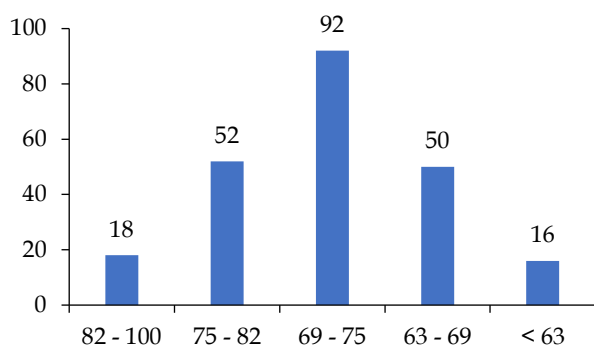


Figure 4. Diagram of self-regulation

Based on Figure 4, it can be seen that self-regulation is in the moderate category with a frequency of 92 students or a percentage of 40.4%. These results indicate that some of the 11th grade MIPA students at SMA Negeri Polewali, Mandar Regency who were respondents have good self-regulation. These results indicate that most students have been able to control their behavior, motivation, and learning strategies, but these abilities have not yet fully developed to their full potential. Self-regulation is an individual's ability to manage the learning process through planning, monitoring, and evaluating activities carried out to achieve learning objectives.

In line with research conducted by Andini & Fitria (2025), it was shown that 64 students (36.36%) had moderate self-regulation. This is in line with research conducted by Fadilah (2021), which showed that students' self-regulation was moderate. In this case, students were able to organize, formulate goals, anticipate potential difficulties in achieving them, and were able to self-evaluate. This is also in line with research conducted by Lai & Hwang (2016), which showed that students with higher levels of self-regulated learning tend to learn more effectively and achieve better results in class. Conversely, students with lower levels of self-regulated learning tend to have poorer self-regulation in the learning process. Achieving moderate levels provides significant benefits in learning because self-regulation supports students in taking responsibility for their learning activities.

Self-regulation can be seen from personal, learning behavior, and environmental aspects. Students with strong self-regulation will naturally develop learning plans, monitor each step of their learning with confidence and responsibility, and evaluate their learning outcomes. This will undoubtedly have a positive impact on learning outcomes, and educators are expected to develop appropriate learning plans and strategies to enhance self-regulation.

Descriptive Analysis of Learning Outcomes

Learning outcomes are changes in behavior or abilities acquired by a person after undergoing a

learning process. These changes can include knowledge (cognitive), skills (psychomotor), and attitudes (affective) as a result of learning experiences. Learning outcomes can also be interpreted as a reflection of learning efforts. The better a student's learning efforts, the better their learning outcomes will ideally be. Therefore, learning outcomes can be a benchmark for assessing a student's learning success (Yandi et al., 2023). Each student's learning outcomes are different. These differences are caused by various influencing factors. Various factors influence student learning outcomes, both internal and external (Duerden & Rowan, 2024).

Students who quickly grasp learning material means that some students quickly understand what has been explained by the teacher, there are also students who have a normal speed in grasping learning material and there are also those who are slow. Therefore, teachers can also evaluate the improvement of students' abilities by knowing what they do during the learning process from beginning to end (measurement). Achievement of the specified standards and can be seen from the tasks that students have completed thoroughly is a teacher's measurement for the achievement of student learning outcomes (Amri, 2013).

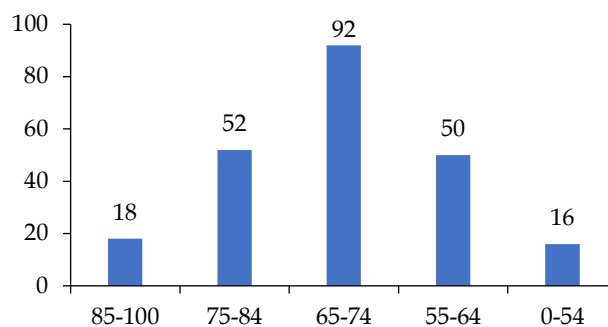


Figure 5. Diagram of Biology learning outcomes

Based on Figure 5, it can be seen that the students' learning outcomes fall into the medium category, with a frequency of 92 students or a percentage of 40.4%. Furthermore, 52 students (22.8%) fall into the high category, and 18 students (7.9%) fall into the very high category. On the other hand, 50 students (21.9%) fall into the low category, and 16 students (7.0%) fall into the very low category. Students in the moderate category demonstrate a reasonably good ability to understand and master Biology material, though they have not yet reached an optimal level of mastery. Meanwhile, the 30.7% of students falling into the high and very high categories indicate that a portion of the students have achieved satisfactory learning outcomes. However, the fact that 28.9% of students remain in the low and very low categories highlights the need for greater attention during the learning process to help these students improve their understanding of Biology concepts.

Consistent with the research conducted by Nasir & Wazithah (2025), student learning outcomes fell into the moderate category, comprising 50 students (25.77% of the total). This aligns with earlier research by Jamaluddin et al. (2025), which indicated that students' biology learning outcomes were in the moderate category, based on an average score of 54.96. These findings suggest that, overall, students' biology learning outcomes fall within the moderate range. This situation may be influenced by various factors ranging from internal factors such as metacognitive awareness, learning independence, self-regulation, learning motivation, and academic ability, to external factors like teacher-implemented instructional strategies, the availability of learning resources, the learning environment, and family support. Therefore, sustained efforts are required to improve the quality of instruction so that a greater number of students can achieve high or very high levels of learning outcomes.

Prerequisite Analysis
Normality Test

The data analysis of the Kolmogorov-Smirnov normality test results on students showed a Sig. value > 0.05. It can be concluded that the scores of the metacognitive awareness, learning independence, and self-regulation variables on students' biology learning outcomes are normally distributed.

Table 3. Normality test results

Normality test results	Sig. (2-tailed)	Description
One-Sample Kolmogorov-Smirnov	0.200	Normality distributed

Linearity Test

Based on the basis of decision making for the linearity test, namely a Sig. value < 0.05, there is a linear relationship between the independent variable and the dependent variable. If the Sig. value > 0.05, there is no linear relationship between the independent variable and the dependent variable. Based on Table 4, it is known that the Sig. value < 0.05, so there is a linear relationship between the independent variable and the dependent variable.

Table 4. Linearity test results

Variables	Sig. Linearity	Information
Metacognitive Awareness *	0.000	Linear
Learning Outcomes		
Learning Independence *	0.000	Linear
Learning Outcomes		
Self-Regulation * Learning Outcomes	0.000	Linear

Multicollinearity Test

Based on the results of the Tolerance value, it is known that the metacognitive awareness variable is

$0.659 > 0.100$, the learning independence variable is $0.636 > 0.100$ and the self-regulation variable is $0.784 > 0.100$. While the VIF value for the metacognitive awareness variable is $1.517 < 10.00$, the learning independence variable is $1.572 < 10.00$ and the self-regulation variable is $1.275 < 10.00$. Based on the reference to the basis of decision making in the multicollinearity test, it can be concluded that there are no symptoms of multicollinearity.

Table 5. Multicollinearity test

Variable	Collinearity Statistic		Description
	Tolerance	VIF	
Metacognitive Awareness	0.630	1.586	There is no multicollinearity
Learning Independence	0.591	1.691	There is no multicollinearity
Self-Regulation	0.751	1.332	There is no multicollinearity

Heteroscedasticity Test

The results of the analysis indicate that the significant value (Sig.) for the metacognitive awareness variable is 0.469. Meanwhile, the significant value (Sig.) for the learning independence variable is 0.405 and the significant value (Sig.) for the self-regulation variable is 0.657. The results of the heteroscedasticity test, obtained a Sig. value > 0.05 on the metacognitive awareness, learning independence and self-regulation variables. In accordance with the basis for decision making in the heteroscedasticity test, it can be concluded that this means that there are no symptoms of heteroscedasticity.

Table 6. Heteroscedasticity test results

Variables	Sig. Linearity	Information
Metacognitive Awareness	0.121	There is no heteroscedasticity
Learning Independence	0.640	There is no heteroscedasticity
Self-Regulation	0.614	There is no heteroscedasticity

Hypothesis Test Results

The Influence of Metacognitive Awareness on Biology Learning Outcomes of Grade XI Senior High School Students in Polewali Mandar Regency

The significance value for the metacognitive awareness variable is 0.000 (< 0.05), indicating an influence of metacognitive awareness on the biology learning outcomes of Grade XI MIPA students at public high schools in Polewali Mandar Regency. The regression coefficient (r) of 0.655 demonstrates the impact of metacognitive awareness on students' biology learning outcomes. Furthermore, the R-square value of 0.429 indicates that metacognitive awareness contributes 42.9% to biology learning outcomes.

Table 7. The influence of metacognitive awareness on Biology learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	30.296	2.891		10.480	0.000
Metacognitive Awareness (X1)	0.549	0.042	0.655	13.018	

Based on the data analysis results in Table 7, the regression equation $Y = a + \beta_1 X_1$ is obtained, namely $Y = 30.296 + 0.549X_1$. Based on the multiple linear regression equation above, the constant (a) has a positive value of 0.549, indicating a directional influence between metacognitive awareness and biology learning outcomes. This indicates that if the other independent variables remain constant or unchanged, the metacognitive awareness variable (X1) contributes 0.549 to biology learning outcomes.

In line with previous research conducted by Ihsan et al. (2024), it shows that there is a positive and significant influence between metacognitive awareness and student learning outcomes. The positive direction of the correlation indicates that the better the student's metacognitive awareness, the better their learning outcomes will be. This is because metacognitive awareness is a person's self-confidence that can be described through learning outcomes in achieving something. This is also in line with research conducted by Adiansyah et al. (2023) which stated that there is a positive and significant influence between metacognitive awareness and student learning outcomes of 12.8%. Increased student metacognitive awareness will be followed by increased biology learning outcomes, while the rest is influenced by other factors. The results of this study are also in line with Flavell's theory which emphasizes that metacognition functions as a controller of the thought process so that it can increase the effectiveness of learning and student academic achievement.

Student success in the learning process is not only influenced by classroom learning but also by various internal and external factors, which can significantly contribute to student learning outcomes (Wardana et al., 2021). Students with metacognitive awareness are more strategic and perform better, enabling them to plan, sequence, and monitor their learning compared to students who are not aware of their metacognition. Teachers also play a crucial role in fostering students' metacognitive awareness. The teacher's role is included among the external factors that can influence student learning success (Fariah et al., 2024).

The Influence of Learning Independence on Biology Learning Outcomes of Grade XI Senior High School Students in Polewali Mandar Regency

Based on the data analysis, it was found that learning independence has a significant effect on biology learning outcomes, with a calculated t-value of 11.692 (exceeding the t-table value of 1.970) and a significance value of 0.000 (below 0.05). The regression coefficient of 0.614 indicates that for every one-unit increase in learning independence, learning outcomes increase by 0.614 units. The R-square value of 0.377 shows that learning independence contributes 37.7% to biology learning outcomes. This magnitude of contribution indicates that learning independence is the variable with the greatest influence compared to other variables. Students with high learning independence tend to be more active in seeking learning resources, disciplined in their studies, and capable of independently overcoming learning difficulties, thereby achieving better learning outcomes.

Table 8. The influence of learning independence on Biology learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	23.172	3.823		6.062	0.000
Learning Independence (X2)	0.618	0.053	0.614	11.692	

Based on the data analysis results in Table 8, the regression equation $Y = a + \beta_2 X_2$ was obtained, specifically $Y = 23.172 + 0.618X_2$. Based on this multiple linear regression equation, the constant value (a) is a positive 0.618, indicating a positive relationship between metacognitive awareness and biology learning outcomes. This implies that, assuming other independent variables remain constant, the learning

independence variable (X2) contributes 0.618 to biology learning outcomes.

In line with previous research conducted by Novitasari et al. (2021), it was stated that there is a significant influence between learning independence and students' biology learning outcomes. The contribution of learning independence is 61%, with 39% influenced by other factors. Students with good learning independence will be able to organize and discipline

themselves, thus taking responsibility for their learning. When students take responsibility for their learning, they will be proactive, creative, and active in learning, and will not be dependent on others.

This is also in line with research conducted by Qadriah et al. (2025), which states that independent learning has a positive and significant effect on students' biology learning outcomes. Therefore, it can be concluded that students with good independent learning are able to work independently without relying on others, behave in a disciplined manner, have self-confidence, believe in their potential, have self-assertiveness, and act based on their own initiative. This is followed by research by Ilmaknun & Ulfah (2023), which states that independent learning has an effect of 61.8% on learning outcomes. This finding supports Knowles' theory, which states that students who are able to direct their own learning process will be more successful in achieving learning goals.

One strategy for fostering learning independence and improving student learning outcomes is through educator support. This aims to help students take initiative in their own learning activities, become less dependent on others, and monitor, evaluate, and organize their own learning activities. Furthermore, students are taught to utilize their time effectively and develop the ability to direct and control their own

thinking and actions, thereby achieving positive learning outcomes.

There are two factors that influence learning independence: internal and external factors. Internal factors that influence learning independence include: Self-concept: students are accustomed to learning when they understand the material provided by the teacher; Motivation: students will always develop pre-existing interests; and Attitude: students demonstrate positive behavior when they are in the community (Lorenzo & Tyas, 2022).

The Influence of Self-Regulation on Biology Learning Outcomes of Grade XI Senior High School Students in Polewali Mandar Regency

The analysis results indicate that self-regulation has a significant effect on biology learning outcomes, with a calculated t-value of 9.343 (exceeding the t-table value of 1.970) and a significance value of 0.000 (below 0.05). A regression coefficient of 0.528 indicates that for every one-unit increase in self-regulation, learning outcomes increase by 0.528 units. The R-squared value of 0.279 shows that self-regulation contributes 27.9% to biology learning outcomes. These results indicate that students' ability to manage their motivation, behavior, and learning strategies plays a crucial role in determining academic success.

Table 9. The influence of self-regulation on Biology learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	29.313	4.124		7.108	
Self-Regulation (X3)	0.529	0.057	0.528	9.343	0.000

Based on the data analysis results in Table 9, the regression equation $Y = a + \beta_3 X_3$ was obtained, specifically $Y = 29.313 + 0.529 X_3$. Based on the multiple linear regression equation above, the constant (a) has a positive value of 0.529, indicating a positive relationship between the self-regulation variable and biology learning outcomes. This implies that if other independent variables remain constant or unchanged, the self-regulation variable (X3) contributes a change of 0.529 to biology learning outcomes.

In line with research conducted by Hastuti et al. (2019), it states that 58% of student learning outcomes are influenced by self-regulation and the remaining 42% are influenced by other variables not explained in this study. This means that the higher the self-regulation, the better the biology learning outcomes of students. Followed by previous research by Salmiah et al. (2025) stated that there is a positive and significant influence between self-regulation and learning outcomes. Therefore, it can be concluded that with good self-regulation, students are able to follow the learning

process with learning independence, organize, control behavior and motivate themselves so that it has a positive impact on the learning outcomes achieved.

Venisa & Sofiyanita (2025) stated that there is a significant influence between self-regulation and learning outcomes of students in the moderate category. Students with this level of self-regulation have quite good abilities in managing the learning process, although there is still a tendency for suboptimal learning. This finding aligns with Zimmerman's theory, which states that self-regulation is a crucial factor in learning success because it helps students effectively control the learning process.

This indicates that the majority of students are in the good category in managing their learning process independently, although many still require guidance. Support for active learning strategies such as group discussions and reflection has been shown to help improve self-regulation, so the teacher's role is crucial in creating a learning environment that encourages student independence.

The Influence of Metacognitive Awareness, Learning Independence and Self-Regulation on Biology Learning Outcomes of Grade XI Senior High School Students in Polewali Mandar Regency

The results of the multiple linear regression analysis indicate that metacognitive awareness, learning independence, and self-regulation simultaneously have a significant effect on biology learning outcomes, with an F-calculated value of 91.624 (exceeding the F-table value of 2.644) and a significance value of 0.000 (below

0.05). The coefficient of determination ($R^2 = 0.551$) reveals that these three variables collectively contribute 55% to biology learning outcomes, while the remaining 45% is influenced by factors not examined in this study. Regarding effective contribution, learning independence makes the largest contribution at 47%, followed by metacognitive awareness at 30% and self-regulation at 23%. This demonstrates that learning independence is the most dominant factor in enhancing students' biology learning outcomes.

Table 10. The influence of metacognitive awareness, learning independence and self-regulation on Biology learning outcomes of grade XI senior high school students in Polewali Mandar Regency

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	8.219	3.828		2.147	
Metacognitive Awareness (X1)	0.335	0.047	0.400	7.087	0.000
Learning Independence (X2)	0.269	0.059	0.267	4.588	
Self-Regulation (X3)	0.238	0.052	0.238	4.597	

Based on the analysis data in Table 10, the regression equation is as follows:

$$Y = 8.219 + 0.335X_1 + 0.269X_2 + 0.238 X_3$$

The value of $a = 8.219$, which means that with metacognitive awareness, learning independence, and self-regulation, student learning outcomes increase by 11.191 units. The coefficient β_1 is 0.335, which means that if metacognitive awareness increases by 1 point while learning independence and self-regulation remain constant, learning outcomes will increase by 0.335, assuming the other independent variables remain constant. A positive coefficient indicates that metacognitive awareness influences biology learning outcomes. The coefficient β_2 is 0.269, which means that if learning independence increases by 1 point while metacognitive awareness and self-regulation remain constant, learning outcomes will increase by 0.269, assuming the other independent variables remain constant. A positive coefficient indicates a relationship between learning independence and biology learning outcomes. The β_3 coefficient is 0.238, meaning that if self-regulation increases by 1 point while metacognitive awareness and learning independence remain constant, learning outcomes will increase by 0.238, assuming the other independent variables remain the same. A positive coefficient indicates a relationship between self-regulation and biology learning outcomes.

Metacognitive awareness, learning independence, and self-regulation play complementary roles in supporting improved student learning outcomes. If students demonstrate a high level of metacognitive awareness, possess learning independence, and demonstrate good self-regulation, this will positively impact the quality of their learning outcomes. These three aspects, when developed together, not only help

students overcome challenges in the learning process but also encourage them to achieve good learning outcomes. In other words, success in learning is greatly influenced by the combination of the ability to persist in the face of and overcome difficulties, the skills to convey and receive information, and the ability to manage their own learning process.

Theoretically, the results of this research show that learning success is not only determined by intellectual ability, but also by students' ability to manage thought processes, regulate learning behavior, and learn independently. These three variables complement each other in forming an effective learning process so as to improve students' biology learning outcomes.

Conclusion

From the results of this study, it can be concluded that: There is a significant and positive influence of metacognitive awareness on the biology learning outcomes of 11th-grade MIPA students at Polewali State Senior High School, Mandar Regency, a moderate influence with a regression coefficient of 0.655. An R-square value of 0.429 indicates that metacognitive awareness contributes 42.9% to biology learning outcomes. This substantial contribution indicates that learning independence is the variable with the greatest influence compared to other variables. There is a significant and positive influence of learning independence on the biology learning outcomes of 11th-grade MIPA students at Polewali State Senior High School, Mandar Regency, a moderate influence with a regression coefficient of 0.614. An R-square value of 0.377 indicates that learning independence contributes 37.7% to biology learning outcomes. There is a

significant and positive influence between self-regulation and biology learning outcomes of 11th-grade MIPA students at Polewali State Senior High School, Mandar Regency, a moderate influence with a regression coefficient of 0.528. The R-square value of 0.279 indicates that self-regulation contributes 27.9% to biology learning outcomes. There is a significant and positive influence of metacognitive awareness, learning independence, and self-regulation on biology learning outcomes of 11th-grade MIPA students at a public high school in Polewali Mandar Regency. The coefficient of determination ($R^2 = 0.551$) indicates that these three variables collectively contribute 55% to biology learning outcomes, while the remaining 45% is influenced by factors not examined in this study. Based on effective contribution, learning independence contributes the largest at 26.2%, followed by metacognitive awareness at 16.3%, and self-regulation at 12.5%. This indicates that metacognitive awareness is the most dominant factor in improving biology student learning outcomes. Based on the results of this study, it is recommended that future researchers expand their research by including other variables that could potentially influence biology learning outcomes, given that 45% of the variation in learning outcomes is explained by factors outside metacognitive awareness, learning independence, and self-regulation. These variables could include learning motivation, learning interest, critical thinking skills, scientific literacy, self-efficacy, parental support, teacher competence, and the learning environment.

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