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The correlation between metacognitive awareness and cognitive learning outcomes based on gender of biology education students

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A R T I C L E   I N F O

A B S T R A C T

Metacognitive awareness has a significant and complex correlation with cognitive learning outcomes. So far, there have not been many studies investigating the correlation between metacognitive awareness and cognitive learning outcomes based on gender. This research aimed at determining the correlation between metacognitive awareness and cognitive learning outcomes based on the gender of biology education students. The samples of this research were biology education students in the third semester of 2020/2021 academic year. The research samples comprised 104 students consisting of 47 male students and 57 female students. The research instruments were used to collect the data of students' metacognitive awareness and cognitive learning outcomes. The results of this research showed that metacognitive awareness had a significant correlation with cognitive learning outcomes both in male students and female students. Metacognitive awareness contributed 66.5% towards the cognitive learning outcomes of male students. This number was greater than that in female students, which was only 39.40%. The results of the ANOVA test showed that the correlation between metacognitive awareness and cognitive learning outcomes in male students and in female students was *not parallel and not coincide.* The results of this research are expected to have effective contributions for educators to continually improve the achievement of learning objectives that emphasize on the development of metacognition and cognition in order to produce competent and quality graduates.

INTRODUCTION

Many studies on metacognitive awareness have been conducted within and outside of Indonesia over the past few decades. However, the focus of these studies is solely on the correlation between metacognitive awareness and the implementation of learning strategies or learning models, metacognitive awareness and learning outcomes, metacognitive awareness and gender equality, metacognitive awareness and educational problems, metacognitive awareness and reading skills, metacognitive awareness and the use of multimedia, or metacognitive awareness and other variables (Akman, & Alagoz, 2018; Aljaberi, & Gheith, 2015; Logan, & Johnston, 2010; Nongtude, & Bhutia, 2017; Tavakoli, 2014; Veloo, Rani, & Hariharan, 2015). However, research on the correlation between metacognitive awareness and cognitive learning outcomes based on gender has never been conducted.

Gender plays a crucial role in science education and is related to the development of one's thinking ability in the learning process (Aini, Rachmatullah, & Ha, 2019; Siswati & Corebima, 2017). Gender refers to the difference in sex or characteristics between males and females (Mahanal, 2012; Mukti, Yuliskurniawati, Noviyanti, Mahanal, & Zubaidah, 2019). The research conducted by Ayazgok & Aslan (2014), Kaur (2017), and Rani, & Govil, (2013) showed no significant correlation between gender and metacognitive awareness. However, Aljarah & Obeidat (2011), Al-oqleh, Teh, Aloqleh, & Mat (2019), and Sabna & Hameed (2016) reported that gender had a significant correlation with metacognitive awareness in both male and female students.

Metacognitive awareness is a part of thinking skills which is essential to be maintained and developed by teachers or students to understand and overcome learning problems (Erlin, & Fitriani, 2018; Pantiwati, & Husamah, 2017). Metacognitive awareness helps students plan, organize, and monitor their learning processes so as to achieve better learning outcomes (Schraw & Dennison, 1994). Students must possess metacognitive awareness in order to organize their own learning and attain academic success. This becomes the central characteristic of lifelong learning (Kallio, Virta, Kallio, 2018).

The research conducted by some experts in metacognition shows that students who have good metacognitive awareness will certainly have better learning strategies and learning outcomes than those who have low metacognitive awareness (Hassan, Samsudin, & Said, 2017; Millis, 2016; Rahman, Jumani, Chaudry, Chisti, & Abbasi, 2010). Because metacognitive awareness affects students' learning outcomes, academic achievement, and future lives, it must be fostered as early as possible (Dos, 2018; Vello, Rani, & K, 2014). The development of metacognitive awareness will assist students in creating effective learning strategies that result in academic achievement (Rahimi, & Katal, 2012).

According to Rahimi and Katal (2012), there exists a positive correlation between the level of metacognitive awareness among students and their cognitive learning outcomes. Cognitive learning outcomes refer to the measurable level of students' actual abilities in terms of concept acquisition, which is a direct consequence of their individual efforts in the learning process (Bahri, Corebima, Amin, and Zubaidah, 2016). The role of metacognitive awareness in enhancing students' cognitive learning outcomes is significant, as it exhibits a positive correlation with such outcomes (Millis, 2016; Gustia & Suhartini, 2021). According to the study conducted by Hermawan, Abidin, and Junedi (2018), there exists a notable association between metacognitive awareness and cognitive learning outcomes.

There is a correlation between students' cognitive learning outcomes and their learning independence (Ardila, Corebima, & Zubaidah, 2013). In accordance with Kuo, Hull, Gupta, and Elby (2013), one of the primary objectives of science education is to assist students in becoming self-directed, efficient, and lifelong learners. Students' metacognitive awareness is correlated with this learning autonomy. Students can use metacognitive awareness to assess their cognitive learning progress and monitor their use of effective learning strategies to achieve their learning goals and objectives (Cubukcu, 2009).

Ormrod (2009) argues that learners' metacognitive awareness improves in proportion to their understanding of the cognitive processes and learning. This has implications for the enhancement of their academic performance and learning process (Schneider & Lockl, 2002). With enhanced metacognitive awareness, students will be more motivated to improve their learning achievement (Millis, 2016).

Enhancing science education is crucial to cultivate students' metacognitive awareness. Under the appropriate guidance, students can be instructed to assume responsibility for their own learning by engaging in planning, monitoring, and evaluating their educational progress (Chiu, 2007; Zohar &

Barzilai, 2013). Students who possess a high level of metacognitive awareness are capable of comprehending and reflecting upon their learning processes. Individuals have a tendency to choose specific learning strategies to successfully accomplish learning tasks. Furthermore, individuals engage in ongoing monitoring of their learning progress, actively seek resolutions to encountered challenges, and engage in self-assessment when completing tasks (Zhang & Goh, 2006).

The gender-related study conducted by Pokay & Blumenfeld (2012) reported that female students had better metacognitive awareness than male students. Female students exhibit a higher level of awareness regarding the significance of self-regulation and possess a greater understanding of how to effectively employ metacognitive strategies to express themselves within the context of classroom learning (Peklaj & Peejak, 2002). However, in terms of problem-solving strategies, male students are superior to the female students in the learning process (Cantrell, & Carter, 2009). Generally, male students tend to have strong visual and kinesthetic intelligence while women tend to have strong verbal skills. The research conducted by Hassan, Samsudin, Said, (2017) showed that students with high metacognitive awareness tended to have high motivation in learning. Therefore, they had better chances to achieve academic success.

Given the available evidence and assertions, it is imperative to undertake a study that places greater emphasis on investigating the relationship between metacognitive awareness and cognitive learning outcomes, specifically with regard to gender, in order to ascertain more precise insights on this subject. The objective of this study was to investigate the correlation between metacognitive awareness and cognitive learning outcomes among biology education students, with a specific focus on gender differences. The anticipated outcomes of this study are poised to provide robust and precise insights for educators or instructors to effectively augment students' metacognitive awareness, thereby yielding improved cognitive learning outcomes.

METHODS
Research Design
This correlational research (Fraenkel, Wallen, & Hyun, 2012), revealed the correlation between metacognitive awareness and cognitive learning outcomes based on gender. The subjects of this research were biology education students in the third semester (III) of the 2020/2021 academic year. Before determining the sample, an equivalence test was done by administering a placement test. Following the placement test, the participants were selected using a random sampling method.

Population and Samples
The research samples comprised 104 students consisting of 47 male students and 57 female students. The research samples were distributed in two private universities in Makassar, South Sulawesi, Indonesia. The samples were selected randomly and had been given an equality test. The research was conducted from September to December in 2021.

Instrument
The data of metacognitive awareness were collected using a questionnaire of Metacognitive Awareness Inventory (MAI) with 34 items. In addition, the data of students' cognitive learning results were collected using an essay test with a total of 14 question items. The question items had been validated by experts before used. The results of construct validation by experts for the MAI questionnaire obtained an average score of 3.67 (very valid category). The validity of the instruments was tested using confirmatory factor analysis, which obtained a factor value of > 0.3 and a T-value of ± 1.96 (all items of metacognitive awareness instruments were declared valid). The Cronbach's Alpha coefficient on the instruments of metacognitive awareness shows a value of 0.961 (declared consistent or reliable). Students' metacognitive awareness was measured using the MAI questionnaire developed by Schraw & Dennison, (1994). This questionnaire consisted of 34 statement items divided into four indicators of metacognitive awareness including planning (9 items), monitoring (11 items), evaluation (9 items), and revising (5 items). This questionnaire used a Likert scale. Table 1 presents the blueprint of the Metacognitive Awareness Inventory (MAI).

Table 1
Blueprint of Metacognitive Awareness Inventory (MAI)

No	Aspect	MAI
1	Planning	1-9
2	Monitoring	10-20
3	Evaluation	21-29
4	Revising	30-34

Procedure

The data of students' metacognitive awareness were collected before the learning process (pretest) and after the learning process (posttest). Learning outcomes data were obtained by giving test questions to respondents at the pretest and posttest. Then the data were analyzed.

Data Analysis Techniques

The research data were initially analyzed using the Kolmogorov-Smirnov Test, to find out whether or not the research data were normally distributed. After that, the research hypothesis was tested using simple linear regression analysis with a significance level of 5%, to determine the correlation and contribution of metacognitive awareness towards cognitive learning results based on student gender.

RESULTS AND DISCUSSION
The correlation between Metacognitive Awareness and Cognitive Learning Results in Male students

The summary of the results of simple linear regression on the correlation between metacognitive awareness and cognitive learning results in male students can be seen in Table 2 to Table 4.

Table 2
The Results of Anova test on Metacognitive Awareness and Cognitive Learning Results in Male Students

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2737,952	1	2737,952	89,332	,000[b]
	Residual	1379,213	45	30,649		
	Total	4117,164	46			

a. Dependent Variable: Cognitive M
b. Predictors: (Constant), Meta

Table 2 shows an F-calculated value of 89.332 with a significance value (0.000) less than 0.05, indicating a correlation between metacognitive awareness and cognitive learning results in male students.

Table 3
Summary of the Regression of the Correlation between Metacognitive Awareness and Cognitive Learning Results in Male Students

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,815[a]	,665	,658	5,53617

a. Predictors: (Constant), MetaM

Table 3 indicates a determination coefficient (R-Square) value of 0.665, suggesting that 66.5 % of Y may be affected by X. The rest 33.5% was influenced by other factors.

Table 4
Regression Equation Coefficient Analysis between Metacognitive Awareness and Cognitive Learning Results in Male Students

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4,066	8,184		,497	,622
	MetaM	1,038	,110	,815	9,452	,000

a. Dependent Variable: CognitiveM

Table 4 shows a constant of 4.066, indicating that Y is 4.066 if X equals 0 (zero). Figure 1 depicts the graph of simple linear regression equation between metacognitive awareness and cognitive learning results in male students.
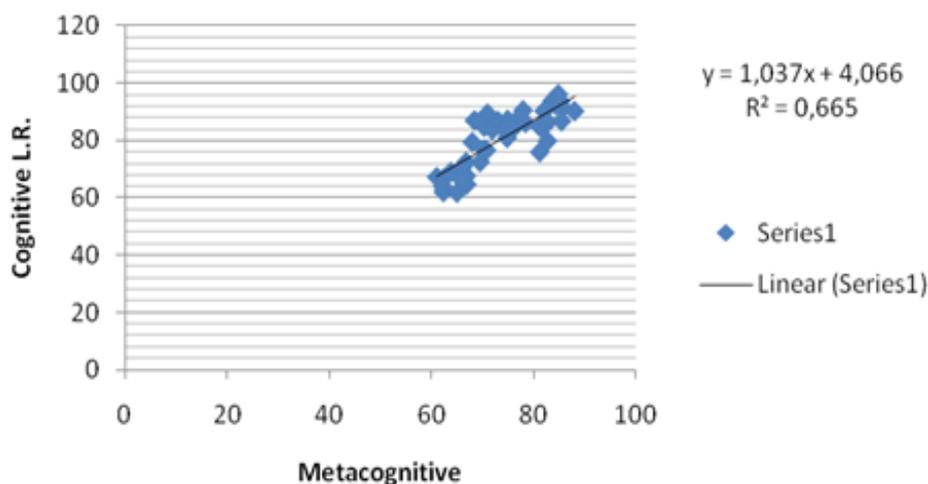

Figure 1. Graph of Simple Linear Regression Equation Between Metacognitive Awareness and Cognitive Learning Results in Male Students

The results of the data analysis show that there is a significant correlation between metacognitive awareness and cognitive learning results in male students (Table 2). In addition, the data in Table 3 show that the contribution value of metacognitive awareness towards the cognitive learning results in male students is 66.50%, with a regression equation Y = 1,037x + 4,066 (Table 4).

The Correlation between Metacognitive Awareness and Cognitive Learning Results in Female Students

The summary of the results of simple linear regression on the correlation between metacognitive awareness and cognitive learning results in female students can be seen in Table 5 to Table 7.

Table 5
The Results of Anova on Metacognitive Awareness and Cognitive learning results in Female Students

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1338,302	1	1338,302	35,231	,000b
	Residual	2051,273	54	37,987		
	Total	3389,576	55			

a. Dependent Variable: CognitiveF
b. Predictors: (Constant), MetaF

Table 5 shows an F-calculated value of 35.231 with a significance value (0.000) less than 0.05, indicating a correlation between metacognitive awareness and cognitive learning results in female students.

Table 6
Summary of the Regression of the Correlation between Metacognitive Awareness and Cognitive Learning Results in Female Students

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,628a	,395	,384	6,16332

a. Predictors: (Constant), MetaF

Table 6 demonstrates a determination coefficient (R-Square) value of 0.395, suggesting that 39.5 % of Y may be affected by X. The rest 60.5% was influenced by other factors.

Table 7
The Regression Equation Coefficient Analysis between Metacognitive Awareness and Cognitive Learning Results in Female Students

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	25,793	8,549		3,017	,004
MetaF	,702	,118	,628	5,936	,000

a. Dependent Variable: CognitiveF

Table 7 shows a constant of 25.79, indicating that Y is 25.79 if X equals 0 (zero). Figure 1 depicts the graph of simple linear regression equation between metacognitive awareness and cognitive learning results in female students.
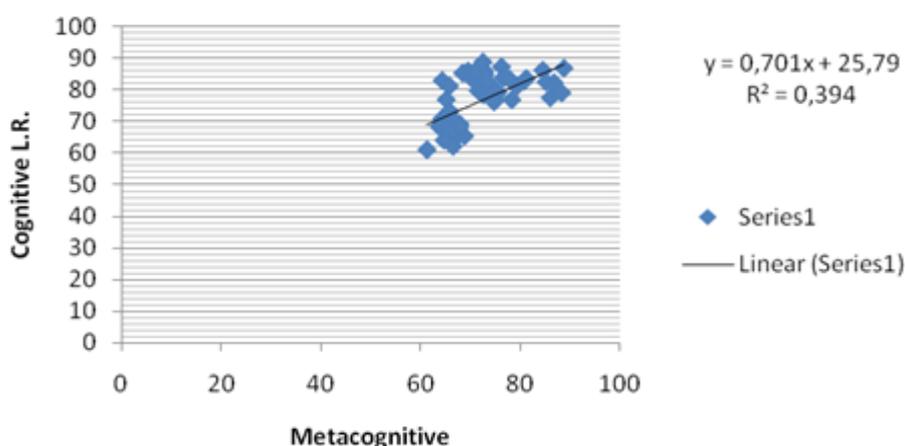

$y = 0.701x + 25.79$
$R^2 = 0.394$

Figure 2. The Graph of Simple Linear Regression Equation of Metacognitive Awareness and Cognitive Learning Results in Female Students

The results of the data analysis show that there is a significant correlation between metacognitive awareness and cognitive learning results in female students (Table 5). In addition, the data in table 6 show that the contribution value of metacognitive awareness towards cognitive learning results in female students is 39.40%, with a regression equation $Y = 0.701x + 25.79$ (Table 7).

Anova Test on the Regression Equations of the Correlation between Metacognitive Awareness and Cognitive Learning Results in Male and Female Students

The summary of the Anova test on the regression equation of the correlation between metacognitive awareness and cognitive learning results in male and female students can be seen in Table 8.

Table 8
The summary of the Anova test on the Regression Equations of the Correlation between Metacognitive Awareness and Cognitive Learning Results in Male and Female Students

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4649,294	3	1549,765	44,724	,000b
	b1, b2	148,1291	1	148,1291	4,27484	0,042
	b1, b2, b3	347,2372	2	173,6186	5,01044	0,008
	Residual	3430,486	99	34,651		
	Total	8079,780	102			

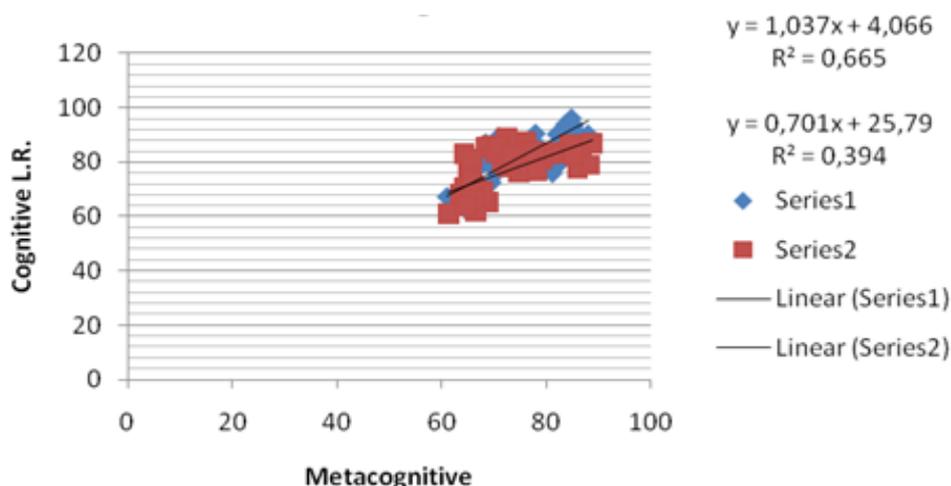**Result:** Not parallel and not coincide

Figure 3. The Graph of the Regression Equations of the Correlation between Metacognitive Awareness and Cognitive Learning Results in Male and Female Students

Description:
Series 1: Male Students
Series 2: Female Students

The results of the Anova analysis show that there is a significant correlation between metacognitive awareness towards cognitive learning results in both male and female students (Table 7). In addition, The graph in figure 3 shows that the results of the Anova test on the regression equations of the correlation between metacognitive awareness and cognitive learning results in male and female students obtained *not parallel and not coincide* regression lines.

The results of the simple linear regression analysis on the correlation between metacognitive awareness towards cognitive learning results in male students obtain a regression equation Y = 1.037x + 4.066. In addition, it was found that metacognitive awareness has a contribution of 66.50% towards the cognitive learning results. Besides, in female students the regression equation is Y = 0.701x + 25.79, and metacognitive awareness has a contribution value of 39.40% towards cognitive learning results, while the remaining percentage is the contribution of other factors which are not examined in this research. The results of this research indicate that the contribution of metacognitive awareness towards cognitive learning results in male students is greater than that in female students. Research by Bogdanovic et al., 2015 found that metacognition and gender were correlated. When compared to boys their age, girls aged fifteen showed greater metacognitive awareness. Additionally, there was a statistically significant positive (r = 0.48473) moderate correlation (P <0.001) between metacognitive awareness and student achievement. There was a significant causal relationship between metacognitive awareness and intellectual risk taking. The mean score of girls on the metacognitive awareness scale is higher than that of boys (Acikgul, Koksal, & Yilmaz, 2022).

The results of this research are in line with the research results conducted by Rahman, Jumani, Chaudry, Chisti, & Abbasi (2010) that the average score of the male students on MAI test is bigger than that of the female students. The results of this research are also supported with the research results conducted by Aljaberi & Gheith (2015) that the average scores of the male students on the five dimensions of metacognitive factors *(Explanatory Knowledge, Conditional Knowledge, Planning, Monitoring and Managing Knowledge)* is bigger that that of the female students. In general, male students have better abilities and are superior in the visio-spatial process than the female students (Sullivan, & Bers, 2013). In addition, male students are more courageous and more prepared in problem-solving strategies than the female students who tend to be more cautious in learning processs (Fenfang, 2010; Saemah et al., 2013). The correlation between students' metacognitive experiences and their cognitive learning outcomes is evident. The average score of male students who are newly enrolled is 62.63, which is greater than the average score of female students, which is 53.37. According to a study conducted by Misu, Masi, and Arviaty (2022), individuals who possess a strong comprehension of a particular concept tend to benefit from enhanced metacognitive experiences, which subsequently facilitates their ability to successfully complete assignments in subsequent learning endeavours. Other

research results also show that male students are superior to female students in their academic abilities, especially in the science learning process (Virtanen & Nevgi, 2010). Male students are more responsive to feedbacks in the learning process, but male students need more time to convince themselves in the changes of performance in learning (Lishinski, Yadav, Good & Enbody, 2016). Further research also showed that female students had significantly more metacognitive knowledge than male students, but male students were better at metacognitive regulation than female students (Panda, 2017). A simultaneous association exists between critical thinking, metacognitive skills, and the academic retention of both male and female students. The impact of critical thinking and metacognitive skills on the retention rates of female students is more pronounced compared to male students (Saleh, Zubaidah, & Mahanal, 2023).

However, the research results conducted by Kusumawati & Nayazik, (2017), and Weaver-Hightower, (2003) found that female students are more concerned with concrete, practical, emotional, and personal things, while male students are more focused on intellectual, abstract, and object things, so that female students are more superior, more accurate and more detailed in working on things than male students. Furthermore, female students tend to use more learning strategies in the learning process, as a result, they have higher intelligence than the male students (Nurmaliah, 2013; MZ, 2013; Supriyadi, Julia & Firdaus, 2019). According to La Misu & La Masi (2017) that the level of metacognitive awareness of female students is better and higher than that of the male students. Similarly, in problem solving strategies female students are superior to male students (Veloo, Rani, & Hariharan, 2015). There are notable disparities in student retention rates between males and females, with the latter exhibiting higher rates of retention (Harrison & Ahuja, 2018).

Gender-related research, such as those conducted by Menevis & Ozad, (2014), and Nongtodu & Bhutia (2017) reports that there is a positive correlation between metacognitive awareness and academic achievement in male and female students, and that there is a significant difference in verbal intelligence, kinaesthetic, musical, interpersonal, intrapersonal aspects between male and female students. In line with these statements, the research findings by Rahman, et al., (2010) found that there is a significant correlation between students' metacognitive awareness and their academic performance. However, there is not any significant difference in metacognitive awareness between male and female students. The corpus callosum of male and female minds is structured differently (Newman & Sharlene, 2015). Women possess a thicker corpus callosum than males. Therefore, women show a greater capacity for multitasking compared to men. Males have a thinner corpus callosum than females, making it more difficult for them to perform multiple duties at once (Newman & Sharlene, 2015).

The results of this research indicate that there is a positive correlation between metacognitive awareness and cognitive learning results both in male and in female students (Tables 3 and 6). These results prove that metacognitive awareness and cognitive learning outcomes are correlated and interrelated. Both have a contribution to each other in increasing metacognitive awareness and improving cognitive learning results in both male and female students. There is a significant and positive correlation between metacognitive awareness towards cognitive learning results and academic success (Das, 2017; Hermawan, et al., 2018). Therefore, it essential that metacognitive awareness and cognitive learning results be empowered to obtain more optimal results. Research suggests that female students have the ability to effectively direct their own learning process in order to enhance their understanding and acquire the necessary skills to determine when and how to employ various learning techniques (Veloo, Rani, & Hariharan, 2014; Sabna & Hameed, 2016). In a study conducted by Sya'bandari, Ha, Lee, and Shin (2019), it was observed that female students exhibited a higher propensity for employing cognitive strategies compared to their male counterparts. Besides, there is a tendency for women to employ critical thinking skills when faced with environmental challenges and circumstances (Arslan, 2012). These factors have an impact on females attitudes, motivation, and time management (Ezeala-Harrison and Ahuja, 2018).

The results of Anova test on the regression equations of the correlation between metacognitive awareness and cognitive learning results in male and female students obtain regssion lines which are not parallel and not coincide (Figure 3). This means that there is a difference in the increase rate of the metacognitive awareness and cognitive learning results between male and female students. The *Slope* value in the male students is greater than that in the female students. This means that the increase of cognitive learning results is influenced by the metacognitive awareness in which the increase in male students is faster than that in female students (Table 7). Therefore, the results of this research show

that the metacognitive awareness of male students develops more quickly than the metacognitive awareness of female students. There exists a significant correlation of 63.4% between declarative knowledge, procedural knowledge, limited knowledge, regulation of cognition, and the ability to design experiments (Handayani & Widiantie, 2020). Gender is a variable that exerts a beneficial influence on the metacognitive skills of students, with female students demonstrating a higher level of awareness (Adiguzel & Orhan, 2017).

Metacognitive awareness is an important predictor of academic performance that affects students' learning results. Students can effectively distinguish which information they already know and which information they do not yet know. As a result, they can review and store information based on their own understanding (Dunning, Johnson, Ehrlinger, & Kruger, 2003; Kruger & Dunning, 1999). Students' metacognitive awareness varies depending on the academic variables each individual has (Ozkan, & Hatice, 2013). Similarly, the reading ability and the cognitive ability between male and female students also have a significant difference (Logan, & Johnston, 2010). In addition, research finding on the academic achievement of the concepts of photosynthesis and respiration in plants also show differences between male and female students, though the difference is not significant (Yenilmez, Sungur, & Tekkaya 2006; Young, & Oxford, 1997). Gender has no significant effect on students' metacognitive awareness (Asy'ari, Mirawati, Zubaidah, & Mahanal, 2022). The affective domain encompasses metacognitive awareness that enables students to use appropriate strategies to solve certain problems, and there are no significant differences between males and females (Sk & Halder, 2020). There is no difference in metacognitive skills between male and female students (Qomariyah & Mistianah, 2020).

The results of this research are in line with the research findings on the correlation between metacognitive awareness, cognitive learning results, and other variables. For example, the research conducted by Mozafari, Safari, Abasifard, Safari, & Sharafi (2016) concluded that there was a correlation between students' metacognitive awareness and academic achievement. Furthermore, research shows the importance of the use of metacognitive abilities including metacognitive awareness to improve students' understanding of concepts or the relationships between concepts in learning. In addition, research results also show a significant positive correlation between students' participation in discussions and their metacognitive awareness (Akman, & Alagoz, 2018; Desoete, Roeyers & Buysse, 2001). Similarly, the research results conducted by Bruckermann, Aschermann, Bresges, & Schluter, (2017) report that there is a difference in the science learning results at the implementation of learning using metacognitive support and cognitive support, because the two variables are interrelated and have their respective roles in the learning process. Metacognitive awareness facilitates students in the process of planning, sequencing, and monitoring their learning endeavours, thereby enhancing their performance directly (Djamahar et al., 2019)

Metacognitive awareness has an important role in improving cognitive learning results (Hermawan, Abidin, Junedi, 2018; Nongtodu & Bhutia, 2017; Rahman, et al., 2010; Rahimi, & Katal, 2012). This is because metacognitive awareness is one of the internal factors that students need to achieve learning success (Kallio, Virta, Kallio, 2018; Rahimi, & Katal, 2012). This statement is supported with previous research findings (Kallio, Virta, Kallio, 2018; Rani, Govil, 2013) stating that metacognitive awareness needs to be developed to improve the quality of learning, which is the main feature of lifelong learners. The greater a student's metacognition, the more conscious they are of the learning process. Additionally, it has been found that metacognition plays a significant role in enhancing one's ability to engage in effective self-reflection (Metcalfe & Schwartz, 2018). The enhancement of students' metacognitive skills can be observed through their capacity to address biological challenges presented by educators (Fauzi & Sa'diyah, 2019).

Cognitive learning results are the results of individual efforts towards what has been learned and can be measured (Bahri, et al., 2016). Learning achievement can be seen from the students' learning results, but the learning results should be related to the cognitive domain of the indicators of the learning objectives (Ardila, Corebima, & Zubaidah, 2013). Cognitive process knowledge was introduced by Flavell (1976) with the term metacognition, and metacognition has a significant correlation with cognitive learning results (Bahri, & Corebima, 2015). In addition to good metacognitive awareness, other factors which students should possess such as reading, asking and answering questions can also improve students' cognitive learning results (Bahri, 2010). Students who obtain good cognitive learning results must also have high metacognitive awareness (Rahman, et al., 2010), and this fact can be seen from the contribution value of metacognitive awareness towards cognitive learning results in this

research ([Table 3](#) and [6](#)). Students need to develop metacognitive awareness and cognitive learning outcomes (Ilma, Al-Muhdhar, Rohman, and Sari, [2021](#)). Metacognition is the awareness of and ability to control one's own cognitive processes (Montillado & Lovitos, [2023](#)).

The increase of cognitive learning results can be affected by both external factors and internal factors possessed by the students themselves. The internal factors include students' learning styles, metacognition, memory, motivation, intelligence, health, interests and talents, while the external factors include schools, families, communities and the environment in which the students live. Metacognitive awareness is included as the students' internal factor which can be developed by the students themselves. The research conducted by Hermawan, Abidin, & Junedi ([2018](#)) concludes that there is a significant correlation between students' metacognitive awareness and cognitive learning results. This is affirmed by Rahman & Philips ([2006](#)) stating that metacognitive awareness has a positive correlation with academic success. Metacognitive knowledge refers to knowledge about thinking processes and information about how to manipulate these processes effectively (Paidi, Djukri, Yulaikah, & Alfindasari, [2017](#)).

In addition, a number of ways have been postulated to develop and increase students' metacognitive awareness and cognitive learning outcomes, such as providing training, implementing appropriate learning strategies or models, providing appropriate motivation and learning styles, strengthening students' talent, monitoring and evaluating learning process, remembering and understanding lessons, increasing knowledge, making plans before and after the learning, repeating lessons, elaborating knowledge, using higher-order thinking skills, asking questions, answering questions, and so on (Abdellah, [2015](#); Adiansyah, Safitri, Bachtiar, [2017](#); Amin, & Adiansyah, [2018](#); Anderson, & Krathwohl, [2001](#); Oz, [2016](#)). If these methods are well and optimally applied, it will have an effect on the improvement of students' metacognitive awareness and cognitive learning results. When an individual initiates the process of monitoring their fundamental cognitive processes during the learning experience, it indicates the utilization of their metacognitive skills. Metacognitive skills facilitate the transfer of acquired knowledge and skills across different contexts or from a prior task to a novel task (Siswati & Corebima, [2020](#)).

The value of *slopes* and *intercepts* in a research can be influenced by various factors including the number of students in the classroom, teacher / lecturer behaviour in the teaching and learning process, student behavior during the learning process, the implemented learning strategies / models, and many other factors (Siswati, [2014](#)). Therefore, every teacher must be able to design explicit learning and make the students aware of the importance of using learning strategy and controlling their own learning and make the students to be more effective in achieving learning success (Rahimi, & Katal, [2012](#)). As a result, the between the students' learning process is, the better their learning results or their academic achievement will be (Schneider & Lockl, [2002](#)).

The results of this research prove that metacognitive awareness has a complex and significant correlation with cognitive learning results. This is because the correlation between metacognitive awareness and cognitive learning results involves metacognitive and cognitive processes, such as, knowledge, monitoring, controlling, planning, and organizing (Aljaberi & Gheith, [2015](#); Rahimi, & Katal, [2012](#); Veenman, Hout-Wolters, & Afflerbach, [2006](#)) to achieve optimal learning objectives, so that it gives effective contributions in both male students and female students. Moreover, further research is required to investigate other factors which may have an effect on the improvement of students' metacognitive awareness and cognitive learning results. The current study was constrained by the limited quantity of research samples available. Hence, it is anticipated that future investigations will encompass a more extensive sample size and a broader scope of research.

CONCLUSION

Based on the results of this research, it can be concluded that there is a significant correlation between metacognitive awareness and cognitive learning results based on gender of Biology Education Students in South Sulawesi, Indonesia. The contribution of metacognitive awareness towards cognitive learning results in male students is bigger than that in female students. The contribution of metacognitive awareness towards cognitive learning results in male students was as much as 66.50% with the regression equation $Y = 1.037x + 4.066$, while the contribution of metacognitive awareness towards cognitive learning results in female students was as much as 39.40%, with the regression equation $Y = 0.701x + 25.79$. The authors express their gratitude to the individuals who have

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