



The Correlation between Critical Thinking and Metacognitive Skills on Student Retention Across Genders in Senior High School

La correlación entre el pensamiento crítico y las habilidades metacognitivas en la retención de estudiantes de todos los géneros en la escuela secundaria

A correlação entre o pensamento crítico e as habilidades metacognitivas na retenção de alunos de ambos os sexos do ensino médio.

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Abstract

[Objective] The current study explored the correlation and contribution of critical thinking and metacognitive skills toward female and male students' retention in senior high school. **[Methodology]** This study used a descriptive correlational design, where critical thinking and metacognitive skills served as the predictor, during retention as the criterion. A total of 230 students participated in this study. The participants comprised 112 (48.70%) male students and 118 (51.30%) female students. An essay test and a scoring rubric were used to collect data on participants' critical thinking and metacognitive skills. The research data were analyzed using a multiple regression analysis at a 5% significance level, followed by ANOVA to examine the contribution of critical thinking and metacognitive skills toward male and female students' retention. **[Results]** The statistical analysis revealed that the simultaneous contribution of critical thinking and metacognitive skills toward female students' retention was higher than that toward male students' retention. The effective contribution values of critical thinking and metacognitive skills toward male students' retention were 2.44% and 10.06%, respectively. Meanwhile, critical thinking and metacognitive skills contributed 7.89% and 12.81% toward female students' retention. **[Conclusions]** There was a simultaneous correlation between critical thinking, metacognitive skills, and retention of male and female high school students. The effective contribution of critical thinking and metacognitive skills toward female students' retention was more significant than that toward male students' retention. The findings of this study suggest that high school teachers need to consider gender equality when implementing learning strategies to improve critical thinking and metacognitive skills.

Keywords: critical thinking skills; metacognitive skills; retention; gender.

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Resumen

[Objetivo] Este estudio tiene como objetivo revelar la relación múltiple entre las habilidades de pensamiento crítico y las habilidades metacognitivas sobre la retención en función del género de estudiantes de secundaria.

[Metodología] Este estudio utiliza un diseño descriptivo correlacional. En el contexto de esta investigación, las habilidades de pensamiento crítico y las habilidades metacognitivas son predictores, mientras que la retención es un criterio. Los sujetos participantes en este estudio fueron 230 estudiantes, de los cuales 112 estudiantes varones (48.70 %) y 118 estudiantes mujeres (51.30 %). El instrumento de investigación utilizado para medir las habilidades de pensamiento crítico, las habilidades metacognitivas y la retención de estudiantes es una prueba de ensayo. Los datos obtenidos se analizaron mediante análisis de regresión múltiple con un nivel de significancia del 5 %. **[Resultados]** Los resultados mostraron que el valor de la contribución simultánea de las habilidades de pensamiento crítico y las habilidades metacognitivas a la retención de las estudiantes fue mayor que el de los estudiantes varones. Las habilidades de pensamiento crítico y las habilidades metacognitivas tienen una contribución de 2.44 % y 10.06 %, respectivamente, a la retención de estudiantes varones. Las habilidades de pensamiento crítico y las habilidades metacognitivas contribuyen en un 7.89 % y un 12.81 % a la retención de las estudiantes, respectivamente. **[Conclusiones]** Existe una relación simultánea entre las habilidades de pensamiento crítico y las habilidades metacognitivas en la retención de alumnos y alumnas. La contribución efectiva de las habilidades de pensamiento crítico y las habilidades metacognitivas de las alumnas es mayor que la de los alumnos varones. Se sugiere que el personal docente debe prestar atención a la igualdad de género al potenciar las habilidades de pensamiento crítico y las habilidades metacognitivas mediante la aplicación de estrategias de aprendizaje adecuadas.

Keywords: Habilidades de pensamiento crítico; habilidades metacognitivas; retención; género.

Resumo

[Objetivo] Este estudo visa revelar a relação múltipla entre as habilidades de pensamento crítico e as habilidades metacognitivas de retenção em função do sexo dos alunos do ensino médio. **[Metodologia]** Este estudo utiliza um desenho descritivo correlacional. No contexto desta pesquisa, as habilidades de pensamento crítico e as habilidades metacognitivas são preditoras, enquanto a retenção é um critério. Os participantes deste estudo foram 230 estudantes, dos quais 112 estudantes eram homens (48,70%) e 118 mulheres (51,30%). O instrumento de pesquisa utilizado para medir as habilidades de pensamento crítico, metacognitivas e de retenção dos estudantes é um teste de ensaio. Os dados obtidos foram analisados utilizando a análise de regressão múltipla com um nível de significância de 5%. **[Resultados]** Os resultados mostraram que o valor da contribuição simultânea das habilidades de pensamento crítico e metacognitivas para a retenção de estudantes do sexo feminino era maior do que o dos estudantes do sexo masculino. As habilidades de pensamento crítico e as metacognitivas têm uma contribuição de 2,44% e 10,06%, respectivamente, para a retenção de estudantes do sexo masculino. As habilidades de pensamento crítico e as metacognitivas contribuem com 7,89% e 12,81% para a retenção dos estudantes, respectivamente. **[Conclusões]** Existe uma relação simultânea entre as habilidades de pensamento crítico e as habilidades metacognitivas na retenção de estudantes do sexo masculino e feminino. A contribuição efetiva das habilidades de pensamento crítico e metacognitivas das estudantes do sexo feminino é maior do que a dos estudantes do sexo masculino. Sugere-se que os professores devem prestar atenção à igualdade de gênero, melhorando as habilidades de pensamento crítico e metacognitivas através da aplicação de estratégias de aprendizagem apropriadas.

Palavras-chave: habilidades de pensamento crítico; habilidades metacognitivas; retenção; sexo



Introduction

Retention refers to a person's ability to hold information in memory after a learning process and within a specific period so that the memory can use again (Chianson, Kurumeh, & Obida, 2011; Ismirawati, Corebima, Zubaidah, & Syamsuri, 2018). Retention is the capacity to store and recall information acquired through learning after a specified period to measure student development (Toklucu & Tay, 2016). Retention refers to all information still retained or remaining in the memory of each individual who has been through the learning process and can be recalled within a specified time frame (McLeod, 2019). Retention refers to an individual's ability to retain all knowledge gained in memory (Eze, Ezenwafor, & Obidile, 2016). Retention indicates whether or not an individual can receive learning effectively. Student retention is directly related to their ability to grasp and recall information (Chakuchichi, 2011).

Retention is vital to the learning process for memorizing and critical thinking, connecting concepts, recalling techniques, and applying knowledge learned during the remembering phase (Toklucu & Tay 2016). Students who have a high retention rate will store material effectively over time and be able to reuse it for the next learning activity (Olurinola & Tayo, 2015). However, retention is a widespread problem that teachers rarely detect because learning activities are often geared at mastering concepts rather than remembering (Ismirawati, Corebima, Zubaidah & Syamsuri, 2018). Retention is a term that relates to the extent to which previously learned material remains embedded in memory. After a specific period, retention can deteriorate rapidly. This decreased retention quality can occur within the first

few hours following the learning process (Toklucu & Tay, 2016).

Retention is connected to memory, a mental process involving acquiring and storing knowledge for it to be retrieved (Olorinola & Tayo, 2015). Several critical components of memory include the following: 1) initial knowledge acquisition, also known as learning or encoding; 2) subsequent information retention; and 3) information recall (Mendonca, 2003). Memory is classified into two types: primary and secondary memory. Primary memory refers to recent events (Andrade & May 2004), also called temporary short-term memory (STM). Meanwhile, secondary memory refers to a persistent and long-lasting memory of an event that occurred some time ago. Long-term memory (LTM) is a term that refers to this sort of memory (Andrade & May, 2004; Artuso & Palladino, 2019). Long-term memory is positioned in the information processing model to encode, store, and recall information (May & Einstein, 2013).

Transferring newly acquired knowledge from short-term to long-term memory causes retention (May & Einstein, 2013). Retention can be measured by the amount of information stored in long-term memory and correctly applied at specific periods or other situations (Sanatullova-Allison, 2014). Memory is the process of encoding, storing, and retrieving information across time (Kadel, 2014). Students can have a strong memory if they can efficiently process knowledge (Andrade & May 2004). Retention can be achieved through meaningful learning, specifically by instructing pupils to connect new and prior knowledge (Chang, Kinshuk, Chen & Yu, 2012).

Critical thinking includes the ability to think reflectively and consider what to



believe and what to do (Ennis, 2011; Arsih, Zubaidah, Suwono, & Gofur, 2021). Critical thinking helps in analyzing, interpreting, evaluating, collecting, and drawing conclusions, as well as explaining and organizing self-activity (Kalelioglu & Gulbahar, 2014; Sarwanto, Fajari & Chumdari, 2021). Critical thinking helps someone make judgments and solve everyday problems (Dowd, Thompson, Schiif, & Reynolds, 2018; Tanjung, Maryani, & Supriatna, 2018). Critical thinking is the capacity to think independently (self-reflect). It is a fundamental (foundational) skill for solving problems, clarifying and enhancing comprehension, and reaching the correct conclusions (Arslan, 2012; Wang & Zeng, 2016).

Students must be able to think critically to voice their perspectives and generate novel ideas (Nasirahmadi, 2014). Critical thinking is a necessary component of the learning process because it helps students develop into solid problem solvers and mature decision-makers (Alghafri & Ismail, 2014; Rodzalan & Saat, 2015). By exercising critical thinking, students can develop their cognitive structures and apply them to real-world challenges (Colley, Bilics, & Lerch, 2012). Critical thinking skills significantly impact students' thought processes, particularly when it comes to problem-solving (Thaiposri & Wannapiroon, 2015). Empowering students' critical thinking skills are vital for developing metacognitive skills (Alper, Karakaya & Yilmaz, 2015). Critical thinking is influenced by metacognitive skills (Magno, 2010).

Metacognitive skills are higher-order thinking skills that pertain to how a person performs cognitive processes (Tuysuzoglu & Greene, 2014). Metacognitive skills are characterized as students' ability to direct and regulate their learning processes

and plan and analyze them (Rivers, 2001; Ramdiah & Corebima, 2014). Metacognitive skills entail monitoring the process of thinking and understanding. Metacognitive skills are higher-order thinking skills that require active control over a student's cognitive processes during the self-study process, in which the student chooses appropriate learning strategies (Sabna & Hameed, 2016; Bahri & Corebima, 2015; Muhali, Yuanita, & Ibrahim, 2019). Metacognitive skills are the ability of students to manage and monitor their learning processes (Tuysuzoglu & Greene, 2014). According to Sanatullova-Allison (2014), metacognition is a mental process that directs the sequential flow of information through sensory, short-term, and long-term memory. As a result of this definition, it may be argued that metacognition contributes to retention. Students' metacognitive skills are critical in characterizing what is known about their cognition (Bryce, Whitebread, & Szucs, 2014). Metacognitive skills are the ability to recognize how to learn or comprehend how to address the challenges encountered when pursuing competency (Knox, 2017).

Metacognitive skills are essential for applying information and regulation to accomplish learning goals (Al-khayat, 2012). Students who possess metacognitive skills can refine their thought processes (Kristiani, Herawati, Rohman & Corebima, 2015). Metacognitive skills enable students to consciously choose and build methods by reflecting on and evaluating their learning (Pennequin, Sorel, Nanty & Fontaine, 2010). Metacognitive skills help students develop into independent learners by encouraging them to become self-managers and judges of their thinking and learning (Stanton, Neider, Callegos & Clark, 2015).



In addition to critical thinking and metacognitive skills, other factors need to be considered in the learning process, one of which is gender (Abraham, 2015). Gender is a broad phrase that encompasses both men and women (Fin & Ishak, 2012). It is a term that refers to the psychological and socio-cultural characteristics that distinguish men and women (Fuad, Zubaidah, Mahanal & Suarsini, 2017). Numerous earlier research studies examining the effect of gender on critical thinking skills, metacognitive skills, and student retention found inconsistent results. For instance, research on the impact of gender on student retention rates demonstrates no statistically significant difference between boys and girls in predicting retention (Eze, Ezenwafor & Obidile, 2016). However, other studies found a substantial difference in student retention between males and females, with female students having higher retention than male students (Divjak, Ostroski & Hains, 2010; Harrison & Ahuja, 2018).

Variances in biological development between genders can result in metacognitive and critical thinking capacity (Ramdiah & Corebima, 2014). According to research, male and female pupils demonstrate identical critical thinking skills (Lukitasari, Hasan & Murtafiah, 2019). However, other research indicates that gender affects pupils' necessary thinking skills (Ricketts & Rudd, 2004). In addition, Liliana & Lavinia's (2011) study demonstrates disparities in metacognition between male and female students, with female students more likely to apply metacognitive strategies than boys.

Gender inequality in the classroom is vital because education should benefit all parties (Tamam, Corebima, Zubaidah, & Suarsini, 2021). Male and female students must have equal opportunities for academic

achievement. In Indonesia, gender inequality has been a prominent concern over the past decade. According to the 2018 Human Development Report, Indonesia ranks 116th out of 189 nations regarding gender disparity. The World Bank (2012) even declared that gender equality is one of the ultimate goals of development.

Several prior studies focused on a particular link between variables, such as the association between critical thinking skills and student retention. The findings indicated that critical thinking skills significantly enhanced student retention (Quitadamo, Brahler, & Crouch 2009). Additionally, research suggests a strong correlation between metacognitive skills and student retention (Nurisyah, Corebima, & Rohman 2016). Naimnule & Corebima (2018) conducted a multiple relationship study and discovered a relationship between critical thinking and metacognitive skills and students' process skills. Additionally, other research indicates a bidirectional relationship between critical and metacognitive thinking skills and student learning outcomes (Wicaksono & Corebima, 2015).

Little research has been conducted to analyze the multiple relationships between critical thinking, metacognitive skills, and student retention across gender. By examining the relationship between critical thinking, metacognitive skills, and student retention, it is feasible to understand better how the two variables interact with accounting for student retention, and thus student retention can accurately predict. The findings of this study are critical for educators and anyone conducting similar investigations. In this case, the relationship between variables, critical thinking skills, metacognitive skills, and retention is far from straightforward. A variable can interact with or be dependent on multiple variables concurrently.



As a result of the previous, a study is required to evaluate the impact of the relationship between critical thinking and metacognitive skills on student retention by gender. The findings of this study may be crucial in assisting teachers in selecting the appropriate learning method or model to increase learning outcomes, critical thinking skills, metacognitive skills, and student retention. Additionally, the findings of this study shed light on the educational curriculum's evolution.

Methodology

Research Design

This study employed a descriptive correlational design. In the context of this study, critical thinking and metacognitive skills were the predictors, while retention was the criterion. This study aimed to reveal the multiple correlations between critical thinking skills, metacognitive skills, and retention in terms of gender.

Participants

The population of this study consisted of all eleventh graders from Jeneponto Regency, South Sulawesi Province, Indonesia. The students were enrolled in the science program in the even semester of the 2018/2019 academic year. The samples in this study were eleventh-grade students from senior high school 1 Jeneponto, senior high school 2 Jeneponto, senior high school 9 Jeneponto, and senior high school 10 Jeneponto. Since the population was sampled randomly without respect for existing strata, each entity had the same opportunity and status. The study involved 230 students, 112 male (48.70%) and 118 female (51.30%).

Research Instrument

An essay test was used to evaluate students' critical thinking, metacognitive, and retention abilities. The test of critical thinking skills, which is integrated with the test of metacognitive skills, consisted of 17 questions about biology learning materials taught to the eleventh graders in Indonesia in odd semesters. The following are some examples of the test questions.

1. *Smoking can endanger lung health and lead to lung cancer and other acute diseases. However, not all smokers suffer from lung disease, and if there is a smoking ban regulation, the tobacco industry will incur enormous losses and layoffs (Termination of Employment) of its employees. In your opinion, is there a need for the government to ban smoking?*
2. *Many foods containing dyes and flavorings are sold to attract consumers' attention. Some people think that artificially colored and flavored foods are suitable for consumption, but others believe these foods are not ideal. What are your thoughts on artificially colored and flavored foods? Justify your position.*

The retention test was conducted to examine participants' long-term memory. The test was administered a month after the learning process of the odd semester of 2018/2019 ended. The test consisted of 17 questions. Some examples of the retention test are presented below.

1. *Bacteria are unicellular organisms capable of surviving in a variety of environments. Some of these environments cannot even serve as habitats for other organisms. Explain how bacteria can survive in extreme conditions.*



2. *Organic and inorganic compounds comprise the chemical constituents of cells. Each element has a distinct role and function that complements the others. Name the organic compounds and inorganic compounds that makeup cells!*
3. *The components, as mentioned above, are interdependent, making them a unit that must maintain. Why is this so? Justify your position!*

Before use, the research instruments underwent expert and empirical validation, including critical thinking, metacognitive, and retention tests. Expert validation was done to examine the content and construct validity of the instruments. Two experts in biology education were invited to perform the expert validation. Meanwhile, the empirical validation was done by 50 eleventh-grade

students from Jenepono. The reliability of the critical thinking, metacognitive, and retention tests were determined using *Cronbach's Alpha*, while the validity was measured using Pearson's correlation test. The tests' validity was evaluated by seeking a correlation between the score on each item and the total score. The correlation coefficient measured the test item's validity, determining whether the item could or could not be used for the study. The validation results showed that the integrated critical thinking and the metacognitive test were valid (0.413) and reliable (0.857). The retention test was also valid (0.355) and reliable (0.820). The results of the validity examination on the critical thinking, metacognitive, and retention tests are shown in Table 1. Meanwhile, the validation results of the retention test are presented in Table 2.

Table 1. *Validity of Integrated Critical Thinking and Metacognitive Skill Test*

Item	Pearson Correlation	Sig. (2-tailed)	Remarks
1	0.604**	0.002	Valid
2	0.449*	0.028	Valid
3	0.546**	0.006	Valid
4	0.687**	0.000	Valid
5	0.446*	0.029	Valid
6	0.738**	0.000	Valid
7	0.685**	0.000	Valid
8	0.457*	0.025	Valid
9	0.475*	0.019	Valid
10	0.439*	0.032	Valid
11	0.581**	0.003	Valid
12	0.477*	0.018	Valid
13	0.704**	0.000	Valid
14	0.632**	0.001	Valid
15	0.470*	0.020	Valid
16	0.624**	0.001	Valid
17	0.652**	0.001	Valid

Note: Own source from the present investigation.



Table 2. *Validity of the Retention test*

Item	Pearson Correlation	Sig. (2-tailed)	Remarks
1	0.368*	0.038	Valid
2	0.565**	0.001	Valid
3	0.668**	0.000	Valid
4	0.568**	0.001	Valid
5	0.651**	0.000	Valid
6	0.547**	0.001	Valid
7	0.517**	0.002	Valid
8	0.597**	0.000	Valid
9	0.540**	0.001	Valid
10	0.531**	0.002	Valid
11	0.375*	0.034	Valid
12	0.469**	0.007	Valid
13	0.451**	0.010	Valid
14	0.489**	0.004	Valid
15	0.559**	0.001	Valid
16	0.417*	0.017	Valid
17	0.595**	0.000	Valid

Note: Own source from the present investigation

Valid and reliable test items were administered to the research participants. The participants' answers to the test questions were evaluated using three assessment rubrics. The critical thinking rubric was developed by Zubaidah, Corebima, & Mistianah (2018) and adapted from the Illinois Critical Thinking Essay Test dan Guidelines for Scoring Illinois of Critical Thinking Essay Test. The 5-scale rubric contained the following indicators: (1) focus, (2) supporting reasons and reasoning, (3) organization, (4) conventions, and (5) integration. Meanwhile, the metacognitive rubric was adopted from Corebima (2008). The 7-scale rubric consisted of the following indicators: (1) answers are original (students using their sentences), (2) answers are coherent, systematic, and logical, (3) answers are written in good grammar or language, (4) answers contain reasons (analysis/evaluation/creation), and (5) answers are correct/less/incorrect/not answered. The retention rubric was adopted by Hart (1994). The rubric has four indicators:

(1) answers are correct and complete, (2) answers are correct but less complete, (3) answers are correct but incomplete, (4) answers are correct but very incomplete, and (5) answers are incorrect or not answered.

Data Analysis

The research data were analyzed using multiple regression analysis at a 5% significance level. Multiple regression analysis was used to determine the correlation between two predictors and one criterium. Following multiple regression analysis, ANCOVA was run to investigate the significance of the contribution of critical thinking and metacognitive skills to male and female students' retention. Before conducting ANCOVA, data normality was examined using One-Sample Kolmogorov-Smirnow, and linearity was analyzed using the Linearity test. All statistical analyses were assisted by SPSS 23 for Windows.



Results and Discussion

The Correlation between Critical Thinking Skills, Metacognitive Skills, and Retention of Male Students

The regression analysis results of the correlation between critical thinking skills and metacognitive skills on male student retention are summarized in Table 3 ($F_{\text{calculated}} = 7.805$ with a significance level of $0.001 < 0.05$). Based on Table 3 shows that critical thinking skills and metacognitive skills significantly correlate with male student retention. Furthermore, Table 4 shows the multiple regression equation $y = 15.545 - 0.204X_1 + 0.505X_2$. Based on the statistical analysis presented in Table 4, metacognitive skills strongly affect male student retention

($\beta = 0.511$, $p = 0.001$). Meanwhile, critical thinking skills have an insignificant negative impact on male student retention ($\beta = -0.233$, $p = 0.120$).

The simultaneous contribution of critical thinking and metacognitive skills to male student retention is 12.5% (Table 5). This result demonstrates that critical thinking and metacognitive skills contribute 12.5%, whereas other not recognized elements contribute 87.5% to student retention. Table 6 summarizes the influence of each predictor variable, namely critical thinking, and metacognitive skills, on male student retention. According to Table 6, the effective contribution of critical thinking skills to male student retention is 2.44%, whereas the effective contribution of metacognitive skills to male student retention is 10.06%.

Table 3. *The Summary of the ANOVA Test on Critical Thinking, Metacognitive Skills, and Retention of Male Students*

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1434.918	2	717.459	7.805	.001 ^b
	Residual	10019.355	109	91.921		
	Total	11454.272	111			

Note: Own source from the present investigation.

Table 4. *The Regression Coefficient of the Correlation between Critical Thinking, Metacognitive Skills, and Retention of Male Students*

Model	Non-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	15.545	3.268		4.756	.000
Critical Thinking Skills	-.204	.130	-.233	-1.568	.120
Metacognitive Skills	.505	.147	.511	3.435	.001

Note: Own source from the present investigation.

Table 5. *The Summary of the Multiple Regression Analysis on Critical Thinking, Metacognitive Skills, and Retention of Male Students*

R	R Square	Adjusted R Square	Std. Error of the Estimate
.354 ^a	.125	.109	9.58753

Note: Own source from the present investigation.



Table 6. *The Effective Contribution of Critical Thinking and Metacognitive Skills on Male Student Retention*

Variable	Relative Contribution (%)	Effective Contribution (%)
Critical Thinking Skills	19.51	2.44
Metacognitive Skills	80.49	10.06
Total	100	12.5

Note: Own source from the present investigation.

The Correlation between Critical Thinking Skills, Metacognitive Skills, and Retention of Female Students

The regression analysis results of the correlation between critical thinking skills and metacognitive skills in male student retention are summarized in Table 7. $F_{\text{calculated}} = 15.018$ with a significance level of $0.000 < 0.05$ suggests that critical thinking and metacognitive skills significantly correlate with female student retention. Table 8 shows the multiple regression equation $y = 10.629 - 0.167X_1 + 0.288X_2$. The statistical analysis indicates that metacognitive skills have a strong and positive effect on female student retention ($\beta = 0.290, p = 0.042$), while critical

thinking skills have a positive yet insignificant impact on female student retention ($\beta = 0.187, p = 0.188$).

Critical thinking and metacognitive skills account for 20.7% of female student retention (Table 9). This result demonstrates that critical thinking and metacognitive skills contribute 20.7% to female student retention, whereas the remaining 79.3% is affected by unmeasured factors. Table 10 summarizes the influence of each predictor variable, namely critical thinking and metacognitive skills, on female student retention. According to Table 10, critical thinking skills contribute 7.89% to female student retention, while metacognitive skills contribute 12.81%.

Table 7. *The Summary of the Anova Test on Critical Thinking, Metacognitive Skills, and Retention of Female Students*

Model	Sum of Squares	Df	Mean Square	F	Sig.	
1	Regression	2193.753	2	1096.877	15.018	.000 ^b
	Residual	8399.346	115	73.038		
	Total	10593.099	117			

Note: Own source from the present investigation.

Table 8. *The Regression Coefficient of the Correlation between Critical Thinking, Metacognitive Skills, and Retention of Female Students*

Model	Non-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	10.629	3.710		2.865	.005
Critical Thinking Skills	.167	.126	.187	1.325	.188
Metacognitive Skills	.288	.140	.290	2.059	.042

Note: Own source from the present investigation.



Table 9. *The Summary of the Multiple Regression Analysis on Critical Thinking, Metacognitive Skills, and Retention of Female Students*

R	R Square	Adjusted R Square	Std. Error of the Estimate
.455 ^a	.207	.193	8.54622

Note: Own source from the present investigation.

Table 10. *The Effective Contribution of Critical Thinking and Metacognitive Skills on Female Student Retention*

Variable	Relative Contribution (%)	Effective Contribution (%)
Critical Thinking Skills	38.11	7.89
Metacognitive Skills	61.89	12.81
Total	100	20.7

Note: Own source from the present investigation.

Multiple regression analyses revealed that critical thinking and metacognitive skills significantly contributed to the retention of both male and female students. In this study, male and female students had equal opportunities to improve their critical thinking, metacognitive skills, and retention. The distinguishing factor between male and female students is the brain's structure (Legato, 2005). The brain structure of men and women has differences in the corpus callosum (Newman & Sharlene, 2015). The corpus callosum is thicker in women compared to men. Consequently, women can multitask more efficiently than men. In contrast, men's corpus callosum is thinner than women's, making it difficult for men to perform multiple tasks simultaneously (Newman & Sharlene, 2015). In general, brain size differs between men and women. Men's brains are more significant than women's (Makarova, Aeschilmann, & Herzog, 2019). These anatomical differences will have ramifications for various modes and styles of behavior, including thinking (Arslan, 2012).

Schraw, Crippen, and Hartley (2006) describe the relationship between critical thinking and metacognitive skills that

influence retention, where critical thinking and metacognitive skills are both necessary to self-regulate learning. The ability to comprehend and manage the learning environment is the same for both. According to Stanton, Neider, Callegos, and Clark (2015), aspects of metacognitive skills can overcome learning difficulties, whereas critical thinking provides reflective feedback as part of the learning cycle to improve student's abilities; therefore, both vital and metacognitive thinking skills contribute in different ways to increase student retention. These results are consistent with Nurisya and Corebima's (2017) research, which demonstrates a significant relationship between critical thinking, metacognitive skills, and student retention. In addition, Naimnule and Corebima (2018) showed that through the application of a learning model, critical thinking and metacognitive skills contribute to students' process skills. Malahayati, Corebima, and Zubaidah (2015) and Wicaksono and Corebima (2015) also indicate a significant relationship between critical thinking skills, metacognitive skills, and biology learning outcomes.

Metacognitive skills are associated with retention, which refers to an individual's



capacity to monitor their cognitive activity on what is known and what should be done. In other words, cognitive processes can aid a person's retention of important information by establishing connections between new and old knowledge (Bahricks & Hall, 2004). Students' retention will improve if they use their metacognitive skills to solve issues directly and autonomously, allowing for the concepts being studied to be retained in memory (Bahri, Idris & Samsidi, 2019). Metacognitive skills are associated with an individual's remembering capacity, in which a person can use his/her abilities based on the events he/she still remembers (Bahricks & Hall, 2004). Metacognitive skills are critical for cognitive tasks such as comprehension, communication, attention, memory, and problem-solving (Arteaga-Martinez, Macias, & Pizarro, 2020).

Student retention can boost with the critical thinking and metacognitive skills required. Students with critical thinking skills will develop metacognitive skills (Amin, Corebima, Zubaidah, & Mahanal, 2020). When students develop their critical thinking skills as part of the learning process, their metacognitive skills also get involved. Students with solid metacognitive skills perform well in critical thinking, independently organizing and processing their learning processes, and comprehending a concept correctly. Information is retained longer in students' long-term memory (LTM). Thus, metacognitive skills positively affect student retention (Nurisya, Corebima, & Rohman, 2017). Metacognitive skills are believed to correlate with retention, which plays an essential role in cognitive activities, including memorization (Daud & Hafsari, 2015).

Memory and retention are inextricably linked to information storage; without the memory process, retention would be

impossible (Nemati, 2009). Retention refers to the knowledge acquired by pupils that can be retained in long-term memory and re-expressed over a specified period (Chakuchichi, 2011). Long-term memory is critical for preserving taught knowledge and recalling relevant thoughts and concepts (Ezeala-Harrison & Ahuja, 2018). Learning activities will be more meaningful through new concepts that must connect to previously learned concepts to boost student retention and be capable of being maintained in long-term memory (Sanatullova-Allison, 2014). Strong memory or retention enables students to store what they have learned in long-term memory (Kamucho, 2005).

Adopting suitable learning strategies can aid in developing critical thinking and metacognitive skills (Adiansyah, Corebima, Zubaidah, & Rohman, 2021). Students can actively form or construct concept findings during the learning process by utilizing proper learning strategies. Additionally, they are urged to retain and increase their memory so that the concept does not slip from their minds. This is critical because retention is one of the keys to academic success (Ismirawati, Corebima, Zubaidah, & Syamsuri, 2018). Metacognitive skills can assist students in developing their critical thinking abilities, affecting student retention via learning strategies (Malahayati, Corebima, & Zubaidah, 2015).

Empowering students' thinking skills through meaningful learning will strengthen their comprehension of a concept, kept in long-term memory, allowing for steady increases in student retention (El-Shaer & Gaber, 2014). Active learning approaches can help boost students' long-term retention (Crossgrove & Curran, 2008). Conducting a retention test has several advantages. Assessing what is previously learned



also contributes to increased retention (Roediger & Karpicke, 2006). Retention is a component of memory critical for the changes in behavior that occur from experience (Chianson, Kurumeh & Obida, 2011). Critical thinking skills require organizing, recalling, and analyzing data internalized through explicit and systematic instruction (Cosgrove, 2011).

Several other multiple relationship investigations, such as those conducted by Mursidah, Susilo, and Corebima, are related to the findings of this study (2019). Previous research indicates a significant correlation between critical thinking skills, communication skills, and student retention in biology classes taught using a particular learning strategy. Additionally, metacognitive skills, motivation, and student retention connect (Widodo, Corebima & Mahanal, 2013). Fauziyah, Corebima, and Zubaidah (2013) findings indicate that metacognitive skills affect learning outcomes and student retention when learning strategies are used. Additionally, Afoan & Corebima's (2018) research demonstrates a link between metacognitive skills, learning outcomes, and retention in biology learning.

According to the statistical analysis, the combined contribution of critical thinking and metacognitive skills to male student retention is 12.5%, while female student retention is 20.7% (Tables 5 and 9). This phenomenon demonstrates that both critical thinking and metacognitive skills insignificantly contribute to the retention of both male and female students. This is due to a variety of reasons, both academic and non-academic. The educational factor refers to the volume of content studied by pupils, which causes students to forget what they previously learned. One of the variables contributing to students failing

previously studied material is an inhibiting problem (Pallennari, 2016). When acquired knowledge or data is combined with new information, inhibiting problems emerge (Pallennari, 2016).

Non-academic factors contributing to pupils' inability to retain information properly are unrelated to the subject, such as motivation. Motivation is an impulse that develops from within an individual, either consciously or intuitively, to accomplish a specific objective (Pintrich, 2003). Motivation will activate and direct a person's conduct to achieve a goal. Motivation affects the degree to which an individual's behavior is intense. Students driven to learn will pay close attention to the lesson, read the material to comprehend the subject, and employ various learning tactics. Motivation motivates students to engage in learning activities, exhibit curiosity, research-specific topics, and submit assignments on time (Bahri & Corebima, 2015).

Another issue affecting critical thinking and metacognitive skills' limited contribution to student retention is teachers' lack of attention to pupils. Attending to students is crucial during the learning process. Due to a lack of teacher attention, students cannot concentrate properly on the subject matter. As a result, student retention cannot thrive. Additionally, teachers do not provide students with the ability to think critically during the learning process. Teachers should emphasize and promote students' development of critical thinking and metacognitive skills as tools for problem-solving and memory improvement (Lujan & Dicarilo, 2006; Chaplin, 2007; Arslan, 2012).

According to Tables 6 and 10, critical thinking skills contribute 2.44% to male student retention and 7.89% to female student retention. This finding suggests that



female students contribute more effectively to critical thinking skills than male students in explaining retention. Female students are more capable of critical thinking, organizing their thoughts, and processing information than male pupils (Bezci & Vural, 2013). Women are inclined to apply critical thinking skills to challenges and circumstances involving the environment (Arslan, 2012). Women influence their attitudes, motivation, and time management (Ezeala-Harrison & Ahuja, 2018).

Another study indicates that women outperform men in problem-solving, but men outperform women in planning, information processing, appraising, task orientation, and self-orientation (Backer, Keer, & Valcke, 2012). Compared to male students, female pupils have more advantages verbally (Divjak, Ostroski, & Hains, 2010; Harrison & Ahuja, 2018). Female students can plan, establish goals, and monitor their educational progress (Bidjerano, 2005). Female students possess superior critical thinking abilities compared to male students (Moafian & Ghanizadeh, 2011). However, some studies indicate no statistically significant difference between male and female students' critical thinking skills (Alper, Karakaya & Yilmaz, 2015).

Additionally, the effective contribution of metacognitive skills to retention is 10.06% for male students and 12.81% for female students (Tables 6 and 10). These findings imply that female students contribute more effectively to metacognitive skills than male students to explain retention. This result is also conceivable because female students can plan, set goals, and monitor their educational progress (Zimmerman & Martinez-Pons, 1990; Liliana & Lavinia, 2011). Female pupils can direct learning most effectively to develop comprehension and recognize when and how to

employ techniques (Veloo, Rani, & Hariharan, 2014; Sabna & Hameed, 2016).

Previous research indicated that female students possessed superior metacognitive skills to male students (Liliana & Lavinia, 2011; Ramdiah & Corebima, 2014; Anandaraj & Ramesh, 2014; Sabna & Hameed, 2016). Female pupils are more adept at problem-solving than male students (Backer, Keer, & Valcke, 2012). According to Zimmerman and Martinez-Pons (1990), women are more capable of controlling and planning their thinking processes. Additionally, Sya'bandari, Ha, Lee, & Shin (2019) found that female students were more likely to apply cognitive methods than male students.

The findings of this study are likely to assist teachers from various disciplines in developing their students' critical thinking and metacognitive abilities in the classroom. This study has shortcomings, chief among which is a single test to assess student retention. Further research can be conducted on similar problems in other urban and rural schools based on their location.

Conclusion

The findings of this study suggest that critical thinking and metacognitive skills contribute significantly toward male and female students' retention levels. The effective contribution of critical thinking and metacognitive skills toward male students' retention levels are 2.44% and 10.06%, respectively. Meanwhile, the effective assistance of critical thinking and metacognitive skills toward female students' retention levels are 7.89% and 12.81%, respectively. Therefore, it is recommended that teachers pay attention to gender equality in the classroom when improving students' critical thinking and metacognitive skills



using appropriate learning strategies. Critical thinking and metacognitive skills are essential for increasing student retention. It is also hoped that the results of this study can provide information and references for education stakeholders interested in enhancing the quality of education and assisting educators in implementing a learning process that considers students' potential.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author contribution statement

The total contribution percentage for this article's conceptualization, preparation, and the correction was R.S. 40 %, S.Z. 30 %, and S.M. 30 %.

Data availability statement

The data supporting the results of this study will be made available by the corresponding author, [S.Z.], upon a reasonable request.

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