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Impact of the Integration of Metacognitive Prompts by Generative Artificial Intelligence (GenAI) in Collaborative and Individual Learning in Improving Writing Skills and Metacognitive Awareness

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Abstract. This study aims to investigate the role of metacognitive prompts by Generative Artificial Intelligence (GenAI) in cooperative and individual learning processes in relation to writing skills and metacognitive awareness. This study used a quasi-experimental method involving 352 high school students. The participants were divided into four groups to examine the integration of metacognitive prompts by GenAI in collaborative writing learning, specifically collaborative writing learning without metacognitive prompts, the integration of metacognitive prompts by GenAI in individual writing learning, and individual learning without metacognitive prompts. The data analysis used MANOVA and two-way ANOVA to investigate the effects of the intervention on the ability to write argumentative essays. The results showed that the integration of metacognition prompts by GenAI in the context of collaborative writing learning was able to improve metacognitive knowledge and regulation most significantly compared to the other intervention groups. In addition, the intervention from metacognition in the context of collaborative learning was able to improve the students' writing skills. The specific improvement in writing ability occurs because the metacognitive prompts received are able to activate the metacognitive process and the ability to use effective strategies in writing. This increase in metacognitive awareness is also able to predict the students' writing ability. In particular, writing ability is more significantly predicted by the aspect of metacognitive regulation than by the aspect of metacognitive knowledge. Therefore, in the setting of collaborative writing, metacognitive regulation is a more meaningful predictor of the students' writing skill. This study has implications for writing teaching practices in terms of encouraging teachers to use

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metacognitive prompts in the context of collaborative learning rather than individual learning.

Keywords: writing learning; GenAI; collaborative and individual learning; metacognitive awareness; metacognitive regulation

1. Introduction

Currently, teachers and researchers have investigated and recommended modifications to several writing teaching methods. Writing skills are one of the productive language skills that have the highest level of difficulty (Chan et al., 2025; Ebadi & Rahimi, 2018). To facilitate students in achieving the goal of learning to write, the focus of teaching writing is to develop a learning environment that can improve the quality of the students' writing skills (Alfaifi, 2022; Karaog, 2017).

However, in reality, teaching writing has many challenges. This is because of the nature of teaching writing, which aims to convince readers through the arguments of the author. Students need to understand the purpose of writing and must have practical experience. Writing abilities don't come naturally; they need to be developed via recursive thought, deliberate work, and a strong dedication to the task (Alfaifi, 2022; Chen & Hapgood, 2019). To achieve the goals of writing, students must build metacognitive awareness for the internalization process and self-correction strategies in order to improve the quality of their writing. Students must also have the competence to revise assumptions, select appropriate syntactic representations, and develop the author's arguments (Cer, 2019; Domokos & Huey, 2023). Writing skills are a self-regulation process that includes several stages, including formulating plans, setting writing goals, organizing ideas, and evaluating.

Based on studies in the field, there are several aspects that cause students to have difficulty when writing, including aspects of writing planning, finding ideas, and text organization (Han, 2024; Kaniel et al., 2000). In addition, students also do not yet have the knowledge and metacognitive control necessary in relation to monitoring and evaluating their writing results. To overcome this problem, students must be facilitated to increase their knowledge awareness and metacognitive regulation skills to improve their writing skills. This self-regulation mechanism aims to activate knowledge, behavior, and emotions in the writing learning process (Noushad et al., 2024; Zhang et al., 2024).

Students must also be involved in the process of internalizing their writing through involving their schemata and using them on assignments, followed by selecting the results of their thoughts before they are expressed in writing. Several studies have shown that metacognitive strategies make a strong contribution to predicting the students' writing skills (Aben et al., 2024; Kim et al., 2024).

These metacognitive strategies include planning, monitoring, reviewing, and evaluating, which are directly involved in the writing process. This metacognition-based instruction can facilitate students in deciding on strategy

adjustments according to the students' writing goals (Han, 2024; Kaniel et al., 2000). There are several differences between the previous studies and the current study, including the metacognitive strategies used in previous studies that have not considered the needs of students in writing. Collaborative learning studies sometimes result in learning that makes students dependent, and where individual student accountability is reduced. The current study is different from the previous one when it comes to overcoming and accommodating the shortcomings of previous studies. The current study integrates metacognitive strategy guidance via Generative Artificial Intelligence (GenAI) in collaborative writing learning. Through the integration of metacognitive strategy guidance by GenAI in collaborative writing learning, it will provide students with opportunities to interact more in the writing learning process.

The purpose of this study is to investigate the integration of metacognitive strategies in collaborative writing learning. This study aims to investigate the integration of metacognitive prompts in collaborative and individual learning in improving the students' metacognitive awareness and writing skills. The researcher put forward three problem formulations as follows:

- a) What is the impact due to the integration of metacognitive prompts by GenAI in collaborative and individual learning on metacognitive awareness?
- b) What is the impact due to the integration of metacognitive prompts by GenAI in collaborative and individual learning on the students' writing skills?
- c) How effective is metacognitive awareness in relation to predicting the students' writing performance?

2. Literature Review

2.1 Metacognition theory study and writing skills

Metacognition strategies have become the focus of researchers and language practitioners because they can improve the quality of language competency teaching. Metacognition has also been found to have a strong correlation with writing ability (Khosravi et al., 2023; Rezai et al., 2023). Metacognition is an ability that refers to student awareness when optimizing their cognitive abilities and regulating the students' mental activities. Metacognition also involves metacognition knowledge and regulation. Metacognitive awareness is the students' awareness and knowledge of the cognitive process which includes three dimensions of knowledge, namely declarative (knowledge of factors that influence learning interactions), procedural (knowledge of task completion procedures), and conditional (knowledge of problem-solving skills) (Parker et al., 2024; Pourdana, 2022).

This metacognitive knowledge includes three dimensions that facilitate the students monitoring and controlling the cognitive processes, including planning, monitoring, and evaluation. Planning includes the use of strategies and the use of appropriate resources when completing tasks. Monitoring is the students' awareness of their monitoring performance and the targets that need to be met to be optimal. Evaluation is the assessment of task quality and efficiency when completing tasks (Gebremariam & Asgede, 2023; Mallahi, 2024). Metacognition is

the students' awareness of the knowledge, experience, and writing learning strategies involved.

Metacognition involves knowing how to reflect and analyze thoughts and how to draw conclusions from the analysis, as well as how to put what has been learned into practice. To solve problems, students often need to understand how their mind functions. In other words, they need to perceive how they perform important cognitive tasks such as remembering, learning and problem-solving (Flavel, 2004). Previous research shows that metacognition training in writing skills has been proven effective through a series of writing learning stages among college students (Apridayani et al., 2024; Fan & Wang, 2024). Students receive metacognition strategy training through several stages, namely planning, monitoring, and evaluating. This is done by giving individual assignments. This training uses comparison and contrast essays.

The research findings show that the writing skills of those who receive metacognition strategy training are superior to those who do not receive training (Allagui, n.d.; Yan & Zhang, 2024). Another study that applied metacognition strategy instruction at the college level included metacognition writing strategies, self-regulation strategies, and text strategies (Peura et al., 2018; Wong et al., 2019). The research findings show that students are able to increase their metacognition awareness, utilize social interaction support in writing, review peer writing, and improve the organization of academic text structures.

2.2 Contribution of metacognition prompts by GenAI in the context of collaborative learning

Metacognition prompts are scaffolds that provide metacognitive instructions to guide students in learning to write. These scaffolds can be assisted by technology or manuals. Based on the results of research on metacognition and collaborative writing studies, teaching focuses on metacognition guidance which may not produce a complex correlation between metacognition and the writing process (Jiang et al., 2021; Zenouzagh, 2020). In addition, instructions in collaborative learning may not achieve the learning objectives due to interdependence, individual accountability, collaboration, and suboptimal evaluations that can hinder collaborative learning. Based on these limitations, researchers recommend using metacognition strategies so then students are trained to regulate their own learning in the context of collaborative learning.

Previous studies have tested metacognition instructions in collaborative learning, as well as metacognition learning without metacognition instruction. The results showed that students who received metacognition instruction and collaborative learning interventions developed better writing skills than the students who only received collaborative learning interventions (Lu & Xie, 2019; Wise et al., 2024). Other studies explored metacognition strategies in the context of groups and individuals towards the achievement of high school level calibration. The results showed that the group calibration of metacognition strategies in groups was better than individual learning (Chan et al., 2025; Ebadi & Rahimi, 2018). Another study also found that the intervention of metacognitive prompt integration in the collaborative learning process was able to improve several aspects including

knowledge of text structure, use of text structure, and minimizing content, and writing abstracts (Rød & Nubdal, 2022; Shahsavar & Asil, 2019).

Self-regulation in the learning process can be improved through learning arrangements by implementing metacognitive strategies. Metacognitive strategies in the context of collaborative learning can be an effective approach to developing collaborative writing experiences. The ability to monitor and self-regulate can be improved through collaboration (Fälth & Selenius, 2024; Kiziltaş & Kultas, 2025). The use of metacognitive strategies in the context of collaborative learning provides opportunities for students to carry out several stages of learning such as asking, demonstrating strategies, and facilitating colleagues to increase metacognitive awareness to determine effective learning strategies (Chen et al., 2019; Zou et al., 2022). This collaborative learning experience facilitates students in improving their self-regulation skills in the writing process.

3. Methodology

3.1 Design and participants

This study used a quasi-experimental method by testing several conditions of the students' metacognitive awareness and writing ability. The study included 352 high school students from multiple schools in Indonesia, ranging in age from 17-20 years old, and in grades 10-12. Four groups of 88 students were formed: one for collaborative writing learning with metacognitive prompts, one for individual writing learning without metacognitive prompts, one for collaborative writing learning with metacognitive prompts, and one for individual writing learning without metacognitive prompts. The independent variables in this study were the context of collaborative and individual writing learning and metacognitive prompting by GenAI. The dependent variables in this study were writing ability and metacognitive awareness.

Based on the combined findings, this study examined four intervention conditions, consisting of three experimental groups and one control group. The experimental groups were incorporating metacognitive prompts into collaborative writing instruction, incorporating metacognitive prompts into individual writing instruction, and avoiding metacognitive prompts in collaborative writing instruction. The control group avoided metacognitive prompts in individual writing instructions. The results of the ANOVA test showed that the four groups' language proficiency was equal, with $F(3, 166) = 1.071$ and $p = 0.71$. From the analysis results, the four groups of students had the same language ability in the phase before the intervention was implemented. To minimize the potential for foreign variables, each group received an intervention that had components adjusted to the intervention conditions. An explanation of the criteria and differences in each group is presented in Table 1.

Table 1: Differences and intervention criteria in each group

Conditions		Criteria
Metacognition Collaboration	+	a) All four interventions were used in the writing instructions.
Metacognition + Individual Collaboration		b) Students received the same writing exercises.
Individual		c) The writing instructor was experienced in all four interventions.
		d) Students received the same material covered in the writing instructions.
		e) For a total of 17 weeks, each of the four interventions was received for the same quantity of time – two and a half hours per week.
		f) The same evaluation techniques were used with all students.
		g) Every student was present in the same classroom. The lecturer provided assistance and urged the students to complete their writing assignments.
Differences between each intervention		
Metacognition Collaboration	+	Students work on writing assignments collaboratively based on the metacognitive prompts given. Conducted for 30 sessions.
Metacognition + Individual		Students work on writing assignments individually based on the metacognitive prompts given. Conducted for 30 sessions.
Collaboration		Students work on writing assignments collaboratively. Conducted for 30 sessions.
Individual		Students work on writing assignments individually. Conducted for 30 sessions.

3.2 Intervention

To further clarify the differences between the interventions in each group, the following is a presentation of each intervention. First is the metacognitive prompt integration group doing collaborative writing learning. The students in this group received a metacognitive prompt from the GenAI intervention in the context of collaboration. The students were formed into study groups, with each group consisting of four people in all sessions. The metacognitive prompts by GenAI consisted of several questions that reveal self-competence according to two aspects, namely metacognitive knowledge and metacognitive regulation. Each group member uses this metacognitive prompt in all phases of the writing practice.

The teacher explains that the answers to the metacognitive prompts by GenAI given can help in writing more effectively. The members in each group collaborate to practice their writing. This collaborative writing includes several stages including planning, drafting, reviewing, and revising the essays collaboratively. The stages start with each student working on a section of the essay, and the group members compiling it. The next stage is the group discussing the essay together and revising it if necessary. The teacher facilitates the students in their groups according to their needs. Second, there is the metacognitive prompt integration

group engaged in individual writing learning. In this group, the students get the same metacognitive prompts by GenAI as the metacognitive integration group engaged in collaborative learning. The writing exercises are carried out individually based on metacognitive prompts produced by GenAI. The teacher uses the first 10 minutes to provide an explanation to all students. Students were given the opportunity to ask questions or ask for help if they encountered any difficulties. Third was the collaborative writing learning group only. In this group, the students practiced writing in groups of four people, involving exercises without getting any instructions or prompts. The writing exercises and division of tasks were the same as the previous group except they did not receive metacognitive prompts by GenAI. Fourth was the individual writing learning group. In this group, the students practiced writing essays individually and did not get any metacognitive prompts. Students can ask questions or ask for help from the teacher if they have any difficulties.

3.3 Research Instruments

The assessments used in this study include writing ability tests and metacognitive awareness inventories. The assessments were conducted using a conventional format. The test time was 50 minutes to complete the writing assignment. Students were also given a metacognitive awareness inventory test according to their respective work speeds. The writing test was argumentative essay writing, which was a general requirement, according to a predetermined topic. Argumentative essays are a type of text that requires the writer to explore a topic or theme and carry out several stages, such as data collection, writing, evaluating the evidence, and determining their position on the topic.

The students were asked to be in one position on one issue and to write by covering several aspects, namely the problem explanation, solution synthesis, and logical argument presentation. The issues chosen were a) young people must remain with their parents after finishing school and b) young people must leave home after completing their education. Writing assessments were conducted before and after the intervention used as pretest and posttest tests. An empirical trial was conducted first with the results of the Cronbach alpha values being 0.79 and 0.82 for the pretest and posttest phases, which means that the instrument has good reliability and meets the criteria.

Next, the students' metacognitive awareness was assessed using the self-report inventory for writing metacognitive awareness. This instrument was adapted from the design of Schraw and Dennison (1994). This instrument focuses on assessing the students' general and specific metacognitive knowledge related to their writing skills. Several statements were revised to suit the interests of the research that focuses on writing metacognition. For example, "Several alternatives about a problem are considered before I write", which was originally a general statement.

Another statement in the metacognitive awareness inventory is "Does my writing meet the goals or criteria that have been determined?" The writing metacognitive awareness inventory includes eight aspects of knowledge, namely declarative

knowledge, procedural knowledge, conditional knowledge, planning, monitoring, and evaluating. The first three aspects are grouped into metacognitive knowledge totaling 19 questions, while the next five aspects are grouped into cognitive regulation (33 statements). The writing metacognitive awareness inventory consists of 52 statements that will be used for data analysis purposes. The construction validity of the items was carried out through expert judgment, specifically by teachers from the field of language with writing specifications. Students received this metacognitive writing awareness inventory in the pre- and post-intervention phases. The results of the analysis showed that the Cronbach's alpha values were .76 and .78 in both phases. These values indicate that the inventory instrument shows acceptable reliability values and is in accordance with the criteria.

3.4 Assessment

The scale of assessment criteria that the assessors agreed upon serves as the basis for the evaluation. Task accomplishment, cohesion and coherence, punctuation, lexical, range, and grammatical accuracy are the five elements that make up the assessment scale. The IELTS assessment scale served as the model for this. The writing evaluation system's punctuation assessment rubric is where the differences lie. The features and degree of the students' writing abilities can be better explained by the writing evaluation that is now in use. A 15-point scale, with three points for each component, was used to assign equal weight to each facet.

Additionally, each statement of the metacognitive awareness inventory was scored on a seven-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), in order to gauge the degree of metacognitive awareness. The metacognitive awareness survey and writing ability exam were evaluated by three instructor assessors. In every intervention group, the assessors never served as teachers. Additionally, the metacognition measure was subjected to an inter-rater agreement test, while 95.2% of respondents passed the inter-rater reliability test on writing outcomes. After discussing the discrepancies, the three assessors were instructed to base their final score determinations on the opinions of the majority.

3.5 Procedure

This study went through several stages. The first stage was when the students took a language test in the pretest phase which addressed reading ability, vocabulary, and writing ability. Based on this pretest, all students involved in this study were determined to have the same abilities. The students who became research participants filled out a form showing their willingness to participate in all stages of the study voluntarily. This study has also received approval from the schools involved and the university. The students took a 45-minute writing ability test and filled out a metacognitive awareness inventory without a time limit in the pretest phase. The second stage was where all participants were divided into four groups that received different interventions. Each group received an intervention for 2 hours each week which was held for 18 weeks. In the last stage, the students took a writing ability test and filled out a metacognitive awareness inventory questionnaire on their writing as a posttest.

3.6 Data analysis

The four conditions involving metacognitive knowledge factors and metacognitive regulation were correlated using MANOVA, one of the data analyses carried out in this study. The effects of the independent variables on the dependent variable were examined using the MANOVA test. Evaluating the possibility of enhancing the capacity to compose argumentative essays was the aim of the study. A two-way ANOVA test was used in the posttest phase to examine the possibility of enhancing the student's argumentative essay writing in both the pretest and posttest stages. Additionally, the predictive effects of metacognitive knowledge, metacognitive control, and the interaction between the two on the students' writing skill were examined using multiple regression testing.

The simultaneous impacts of the independent variables on the dependent variable were also examined using multiple regression. The relationship between the variables in this regression model may be seen through the interaction effect. Metacognitive knowledge and regulation are two independent variables that were tested simultaneously. The changes that the independent factors create in the dependent variable of writing skill were used to evaluate the impact of this interaction. Bonferroni correction was also employed in this study to lower the number of multiple comparison analysis errors. The effect size employed partial η^2 , and the significance p value was found to be 0.05.

4. Results

Based on the results of the ANCOVA analysis, in the pretest phase, there was no significant difference found in the metacognitive knowledge of the four intervention groups with a value of $[F(3, 168) = 1.97, p = 0.56]$, while the metacognitive regulation value showed a value of $[F(3, 168) = 1.84, p = 0.60]$. In the pretest phase, the students' abilities had the same level of metacognitive awareness to avoid bias in the research results. An analysis was carried out in the posttest phase to determine the impact of the four interventions on metacognitive knowledge and regulation. The results of the analysis are presented in Table 2.

Based on the results, the metacognitive knowledge value in the posttest phase was in the range of 1.16 to 4.42, and the value in metacognitive regulation was in the range of 2.38 to 6.42. The next stage was a MANOVA test with an equality test examining the Covariance Matrix with a value showing $(M = 48.312, F = 6.241, p < .001)$. The covariance matrix was not the same. This value indicates that the null hypothesis was violated. The next stage was the use of Pillai's criteria in the multivariate test to investigate the impact of the four interventions on metacognitive awareness.

Table 3 displays the multivariate metacognition test results. The metacognitive prompts had a significant impact on the students' metacognitive awareness, according to the findings $(V = .841, F(2, 168) = 272.040, p < .001, \text{partial } g^2 = .78)$. With a value of $V = .825, F(2, 166) = 264.211, p < .001$, and $\text{partial } g^2 = .78$, it was also discovered that the collaborative versus solo learning environment had a

substantial impact on the students' metacognitive awareness. With values of $V = .120$, $F(2, 166) = 12.254$, $p < .001$, and partial $g^2 = .13$, the interaction between the metacognitive prompts by GenAI and the learning environment also significantly impacted metacognitive awareness. To examine the impact of the four interventions on the two facets of metacognitive awareness, the researcher first performed a multivariate test and then a univariate test. Table 4 displays the findings of the univariate test. The findings indicated that metacognitive prompts had a significant impact on metacognitive knowledge, with a value of $[F(1, 170) = 297.325, p < .001, \text{partial } g^2 = .65]$. Metacognitive knowledge was also significantly impacted by the learning environment, as evidenced by the value $[F(1, 170) = 263.423, p < .001, \text{partial } g^2 = .60]$.

With a value of $[F(1, 170) = 1.925, p = .19, \text{partial } \eta^2 = .01]$, the interaction between metacognitive prompts and the learning process environment did not, however, have a significant impact on metacognitive knowledge. Additionally, metacognitive prompts were shown to have a considerable impact on metacognitive regulation, as evidenced by a value of $[F(1, 170) = 425.030, p < .001, \text{partial } g^2 = .73]$. $[F(1, 170) = 442.223, p < .001, \text{partial } \eta^2 = .73]$ was the effect of the learning environment on metacognitive control, and $[F(1, 169) = 23.452, p < .001, \text{partial } g^2 = .13]$ was the effect of the interaction between the two.

Table 2: Descriptive statistics of metacognitive knowledge and metacognitive regulation in the posttest

Metacognition	Conditions	Mean	Std. deviation	N
Knowledge of metacognition	Individual	1.16	.350	88
	Collaborative	2.78	.762	88
	Metacognition Individual	+ 2.99	.791	88
	Metacognition Collaborative	+ 4.42	.631	88
Regulation of metacognition	Individual	2.38	.632	88
	Collaborative	4.84	.734	88
	Metacognition Individual	+ 4.80	.620	88
	Metacognition Collaborative	+ 6.42	.533	88

Table 3: Multivariate test of metacognition

Effect	Value	F	Hypothesis df	Error df	Sig	Partial n2
Metacognitive prompts by GenAI						
Pillai's trace	.841	272.040	2	168	.000	.78
Learning setting (collaborative and Individual)						
Pillai's trace	.825	257.211	2	168	.000	.78
Metacognitive prompts by GenAI x learning setting						
Pillai's trace	.120	12.254	2	168	.000	.13

Table 4: Results of the univariate metacognition tests

Source	Type III sum of squares	df	Mean square	F	Sig	Partial n2
Metacognitive prompts by GenAI						
Metacognitive knowledge	135.326	1	135.326	297.325	.000	.65
Metacognitive regulation	172.452	1	172.452	425.030	.000	.72
Learning setting						
Metacognitive knowledge	113.459	1	113.459	263.423	.000	.60
Metacognitive regulation	182.050	1	182.050	442.223	.000	.73
Metacognitive prompts by GenAI * learning setting						
Metacognitive knowledge	0.857	1	0.857	1.925	.190	.01
Metacognitive regulation	9.569	1	9.569	23.452	.000	.13

Post hoc analysis was conducted by adjusting the average value based on pairwise comparison. Based on the analysis results, it was found that the metacognitive prompt integration group in the collaborative learning group showed significantly better metacognitive knowledge than the other intervention groups with appropriate p values for each metacognitive prompt group in individual learning ($p = 0.05$), collaborative writing learning group ($p: 0.05$), and individual writing learning ($p: .001$). The average value of metacognitive awareness in pairs was also found, namely how the metacognitive prompt by GenAI group in individual writing learning was better than the individual writing learning group alone with a p value of 0.05. Students in the collaborative writing learning group showed better metacognitive awareness than individual writing learning with a p value of 0.05. The analysis of metacognitive regulation in each intervention group was as follows. Students in the metacognitive prompt by GenAI group in collaborative writing learning showed a more significant improvement than the

metacognitive prompt by GenAI group in individual writing learning ($p: 0.05$), collaborative writing learning ($p: 0.05$), and individual writing learning ($p: 0.05$).

In addition, it was also found that metacognitive regulation in the metacognitive prompt by GenAI group with individual writing learning was superior to metacognitive regulation in the individual writing group alone. Metacognitive regulation in the collaborative writing learning group was better than the individual writing learning group. A two-way ANOVA test was conducted to investigate the differences in the impact of metacognitive prompt integration in collaborative and individual learning on writing ability. Before conducting the analysis, the researcher conducted an analysis of the differences in writing ability in the pretest phase. Based on the results of the analysis, no significant differences were found in the pretest conditions with a value of $[F(3, 168) = 1.62, p = 0.68]$. In the posttest phase, the writing ability of each group showed significant differences.

The results of the analysis of writing ability for each group are presented in Table 5. Based on the results of the analysis, students in the metacognition prompt group doing collaborative writing learning showed the best writing ability compared to other groups with a value of ($M = 13.68, SD = 0.924$), followed by three other groups, namely the metacognition prompt group in individual writing learning with a value of ($M = 11.52, SD = 0.831$), the collaborative writing learning group with a value of ($M = 9.14, SD = 1.284$), and the individual writing group with a value of ($M = 7.45, SD = 1.20$).

To investigate the impact of the group on writing ability, a two-way analysis of variance test was conducted. Based on the results of the Levene test of equality of variance, it was found that the assumption value of the same variance was in accordance with the criteria with a value of $[F(3, 167) = 1.824, p = 0.167]$. An analysis of the inter-subject effect test was carried out, which is presented in Table 6.

Table 5: Results of the descriptive statistical analysis of writing ability in the posttest phase

Conditions		Mean	Std. deviation	N
Individual		7.45	1.20	88
Collaborative		9.14	1.284	88
Metacognition Individual	+	11.52	.924	88
Metacognition Collaborative	+	13.68	.924	88
Total		10.75	3.148	352

Table 6: Test of the inter-subject effects on writing ability

Source	Type III sum of squares	df	Mean square	F	Sig	Partial η^2
Metacognitive prompts	521.783	1	521.783	482.765	.000	.76
Learning setting	171.462	1	171.462	167.426	.000	.52
Metacognitive prompts by GenAI * learning setting	5.263	1	5.263	5.782	.029	.03

Table 7: Multiple regression test on the contribution of metacognitive awareness to writing ability

Variables	B	Std. error	b	Sr ²
Writing outcome				
Metacognitive knowledge	.584**	.382	.462	.28
Metacognitive regulation	.542**	.157	.463	.50
Metacognitive knowledge * Metacognitive regulation	.198**	.050	.960	.089
Model summary	Intercept = 6.342			
	R ² = .824			
	Adjusted R ² = .73			
	R = .89			
	Std. Error of the Estimate = 1.082			

Based on the results of the analysis of the inter-subject effect test shown in Table 6, a significant impact due to metacognitive prompts was found with a value of $[F(1, 170) = 482.765, p < .001, \text{partial } g^2 = .76]$, the impact of the learning environment with a value of $[F(1, 170) = 171.462, p < .001, \text{partial } g^2 = .52]$, and the impact of the interaction between metacognitive prompts by GenAI and the learning environment on writing ability $[F(1, 170) = 5.782, p < .05, \text{partial } g^2 = .03]$. Based on the post hoc test, it was found that the writing ability in the metacognitive integration group in collaborative writing learning was comparable to other groups.

In addition, students who used metacognitive prompts showed as having better writing skills than the students who received individual writing learning interventions. Students who received collaborative learning interventions showed better abilities than the group of students who received individual writing learning interventions. Multiple regression analysis was conducted to investigate the effectiveness of metacognitive awareness in predicting writing ability. The results of the analysis are presented in Table 7. Based on the results of the analysis,

metacognitive knowledge and regulation have a significant impact. In addition, the interaction between metacognitive knowledge and regulation also has a significant impact on writing ability.

5. Discussion

This study aimed to investigate the impact of four interventions on the students' metacognitive abilities and writing abilities. In addition, this study also investigated the predictive impact of metacognitive awareness on writing ability. In terms of metacognitive ability, the results of the study indicate that the intervention of metacognitive integration in collaborative writing learning has the most significant impact on improving metacognitive knowledge and regulation.

This finding is in line with the results of previous studies that prove that the students' self-regulation can be improved through metacognitive prompts integrated into the curriculum and group learning (Karaog, 2017; Leggette et al., 2019). Collaborative learning arrangements can facilitate students in understanding the use of metacognitive strategies. Students who receive metacognitive instructions from GenAI in collaborative learning mean that the students will get different interpretations that result in negotiations on the meaning of the learning materials.

In addition, provocative questions can also create negotiations. In the learning process, questions can encourage students to reflect on the learning process which can increase metacognitive awareness, so that they plan, monitor, and evaluate their writing results. This finding is in line with the findings of previous studies that have revealed that the key to collaborative learning consists of several elements including scaffolding, provocative questions, reflective models, feedback, monitoring, and evaluation (Alfaifi, 2022; Chen & Hapgood, 2019).

The next finding is that students who receive metacognitive prompts from the GenAI intervention in the context of collaborative writing learning make the most significant contribution to their essay writing skills compared to other interventions. This improvement in writing skills occurs because the metacognitive prompts they receive are able to activate the metacognitive process and their ability to use effective strategies in writing. This is reinforced by previous findings which have revealed that metacognitive prompts by GenAI have a significant effect on writing skills (Dixon & Cox, 2025; Kim et al., 2024).

In addition, metacognitive prompts are also able to facilitate students in the implementation of writing strategies that simultaneously use regulatory skills to optimize their writing skills. Metacognitive prompt interventions by GenAI are able to facilitate students to reflect on the writing strategies they use, helping students use their resources. This process will encourage students to progress through several stages such as monitoring, evaluating, and reflecting on their writing after the work is completed. This is in accordance with previous studies which have revealed that this metacognitive prompt training makes a significant contribution to improving the students' writing skills and writing quality (Chan et al., 2025; Noushad et al., 2024). The improvement of their writing ability

through metacognitive prompts occurs because the prompts are able to facilitate the students in constructing a repertoire of writing strategies and metacognitive regulation enhancers which are able to increase the students' sensitivity to the correlation between metacognitive prompts and writing quality.

The results of this study also show that the collaborative learning environment encourages students to interact with their friends so then they are motivated to reason and negotiate when working on essay writing assignments. Findings about the contribution of collaborative writing learning can be found in previous studies. Students engaged in this collaborative writing learning are encouraged to be able to carry out several activities such as planning, drafting, reviewing, and improving their writing exercises (Fälth & Selenius, 2024; Kiziltaş & Kultas, 2025). This collaborative activity is able to construct and improve the students' abilities in combining ideas and peer feedback, as well as the students' self-regulation abilities. These abilities facilitate the students in identifying differences between the quality of their writing and the quality of their expectations so then the students can be more effective when it comes to analyzing and correcting errors after the writing process.

The findings of the intervention's contribution regarding the integration of metacognitive prompts by GenAI in collaborative learning on writing ability occur because of the operation of metacognitive prompts in the collaborative learning environment simultaneously. This finding is in line with metacognition theory which states that metacognition prompts by GenAI in the context of collaborative learning will facilitate students in understanding information in the writing process, meaning that the students' cognitive burden is reduced and produces better quality writing (Evmenova et al., 2024; Zou et al., 2022).

The next finding is that metacognitive knowledge and regulation are able to predict the quality of the students' writing skills. Increased metacognitive awareness is strongly correlated with increased writing skills. This finding is in line with previous studies that found that metacognition is a strong predictor in academic learning (Alfaifi, 2022; Cer, 2019). Metacognitive awareness contributes to the students' ability to manage their cognitive resources, analyze their weaknesses and strengths in terms of writing skills, and engage with effective strategies. Students with good metacognitive awareness are able to determine writing goals and use appropriate strategies in planning, monitoring, and evaluating their writing results. The selection of effective strategies is also influenced by the students' metacognitive awareness (Kaniel et al., 2000; Zhang et al., 2024).

However, when the use of writing strategies is not yet effective, students can adjust until their use of writing strategies is considered effective. This finding is in line with previous studies that show that students with low metacognitive awareness are unable to determine writing goals and have difficulty planning, monitoring, and evaluating writing properly (Domokos & Huey, 2023; Han, 2024). Specifically, metacognitive regulation is a better predictor of writing skills than metacognitive knowledge. Metacognitive regulation is the ability to self-regulate

in planning, monitoring, and evaluating the students' ideas. This ability contributes significantly to writing skills. The positive impact of metacognitive regulation is supported by several previous studies. Students with good metacognitive regulation skills tend to be better able to modify metacognitive writing strategies, making it easier to choose strategies, use resources, and monitor and evaluate their writing.

6. Conclusion, Implications, and Recommendation

From the results of this study, it can be concluded that the integration of metacognition prompts by GenAI in the context of collaborative writing learning is able to increase metacognitive knowledge and regulation most significantly compared to other intervention groups. In addition, the intervention of metacognition in the context of collaborative learning is able to improve the students' writing skills. This increase in writing skills and metacognitive awareness occurs because metacognition in collaborative learning facilitates the processing of information and development of metacognitive awareness among the students, reflecting in the improvement of the student's writing. The increase in writing skills specifically occurs because the metacognitive prompts by GenAI that they receive are able to activate the metacognitive process and their ability to use effective strategies in writing. This increase in metacognitive awareness is also able to predict the students' writing skills.

In particular, writing skills are more significantly predicted by the feature of metacognitive regulation than by the component of metacognitive knowledge. This study has implications for the practice of teaching writing as it encourages teachers to use metacognitive prompts by GenAI in the context of collaborative learning rather than individual learning. This study also has implications for teaching practices regarding the use of appropriate scaffolding in teaching writing. The use of GenAI for metacognitive prompts can be used in various language skills teaching. This study has several limitations, including that the participants were limited to junior high school level and that their number was limited. There was no qualitative analysis revealing student performance during collaboration and cognitive behavior, and the focus of the text types was on argumentative essays.

Based on the limitations of this study, the researcher recommends several things for future research, including the participants needing to be tested at high school or college level with more varied student backgrounds, the engagement of qualitative analysis to result in more comprehensive findings, and the need to test this result in relation to other types of text. This study contributes to the practice of teaching writing, showing that the integration of metacognitive prompts by GenAI in collaborative learning is more recommended due to improving writing skills than it is in individual learning.

7. References

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