

Metacognition and Critical Thinking Among Indonesian College Students: Examining the Role of Cognitive Load as a Moderating Factor

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ABSTRACT

This study examined whether cognitive load moderates the relationship between metacognition and critical thinking among students in Indonesia. A total of 201 undergraduate and diploma students participated by completing an online questionnaire using the Indonesian version of the Metacognitive Awareness Inventory (MAI), the Leppink et al. adaptation of the Cognitive Load Scale, and the Sosu adaptation of the Critical Thinking Disposition Scale. Results showed that metacognition had a significant positive effect on critical thinking ($p < .001$), explaining approximately 47-50% of the variance across models. However, intrinsic, extraneous, and germane cognitive load did not significantly moderate this relationship. The interaction between metacognitive awareness and critical thinking disposition remains stable across varying levels of perceived cognitive load. These findings highlight metacognition as a robust predictor of critical thinking disposition and suggest that perceived cognitive load may not substantially alter this relationship at the dispositional level. Rather than contradicting Cognitive Load Theory, the results refine its applicability by indicating that cognitive load effects may be more observable in performance-based contexts. Future research may explore whether cognitive load exerts stronger moderating effects on performance-

based critical thinking tasks under experimentally manipulated conditions.

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1. INTRODUCTION

Higher education in the digital era requires students to engage with academic literature, evaluate empirical evidence, and construct discipline-based arguments as part of expected academic learning outcomes. Critical thinking has therefore become a central competency, as students must evaluate information, identify underlying assumptions, and develop well-supported conclusions that guide academic and everyday decision making (Golden, 2023; Scott, 2015). Students who lack these skills are more vulnerable to cognitive biases, misinformation, and poor decision-making (Bensley, 2023; Dwyer et al., 2025). In contrast, students with strong critical thinking abilities demonstrate better academic achievement, enhanced problem-solving capability, and improved adaptability in complex real-world contexts (Akpur, 2020; Hwang et al., 2023; Ku & Ho, 2010). In addition to academic outcomes, these skills have also been linked to professional readiness and broader social engagement (American Management Association, 2020; Bensley, 2023; Terblanche & De Clercq, 2021). Consequently, fostering critical thinking remains a central objective of higher education.

Critical thinking does not operate independently from other cognitive processes. A substantial body of research identifies metacognition as one of the strongest predictors of critical thinking (Akcaoglu et al., 2023; Dwyer et al., 2025; Heijltjes et al., 2014; Zepeda & Nokes-Malach, 2023), even when controlling for differences in working memory capacity and domain expertise (Li et al., 2024). Metacognition or metacognitive refers to an individual's awareness and regulation of their cognitive processes (Schraw & Dennison, 1994). Through planning, monitoring, and evaluation, metacognitive regulation enables learners to adjust

strategies, detect reasoning errors, and construct more logically coherent arguments (Efklides, 2020; Zohar & Barzilai, 2013). When students engage in critical thinking, they need metacognitive processes (Dessie et al., 2023; Dwyer et al., 2025; Ku & Ho, 2010; Yang & Luo, 2025). Thus, metacognition functions as a regulatory mechanism that supports higher-order thinking.

However, the effectiveness of metacognition is constrained by cognitive resource limitations. Cognitive Load Theory states that working memory has a limited capacity, which affects how individuals process and learn complex information (Paas & Van Merriënboer, 2020; Sweller, 1988). Cognitive load is commonly categorized into intrinsic, extraneous, and germane load (Leppink et al., 2013). Intrinsic load reflects task complexity, extraneous load arises from suboptimal instructional design, and germane load represents cognitive effort devoted to schema construction. When cognitive load is elevated, students may experience diminished cognitive resources for metacognitive monitoring and strategy modification. Studies indicate that heightened task complexity may diminish metacognitive awareness and hinder performance (Zeitlhofer et al., 2024). Other research suggests that a modest load may facilitate deeper processing and self-regulation (De Bruin et al., 2025; Seufert et al., 2024). These mixed results suggest that cognitive load can influence how well metacognitive methods contribute to learning and reasoning.

Research conducted in Indonesia reported a positive relationship between metacognitive awareness and critical thinking in students (Cendana & Harjono, 2021; Chumdari et al., 2023; Murtadho, 2021). At the same time, evidence indicates that students' critical thinking dispositions remain relatively low in certain instructional settings, particularly in problem-based learning settings (Rahayu et al., 2019). Additional studies demonstrate that cognitive load can moderate the relationship between self-regulation strategies and learning outcomes (Seufert et al., 2024) and influence how students use metacognitive strategies during problem solving (Cholily et al., 2024). Furthermore, students who can handle their cognitive load well actually help them regulate themselves (Gorbunova et al., 2024), and increases in cognitive load during online learning contexts in Indonesia have been associated with reduced learning effectiveness (Mauluddin & Fahmi, 2025). These findings highlight the

importance of examining how cognitive demands interact with regulatory processes in higher education.

Despite these developments, several important gaps remain. First, existing research often examined metacognition and critical thinking as a direct predictor of performance, separately from cognitive load, or treated cognitive load primarily. Second, limited empirical attention has been given to how intrinsic, extraneous, and germane load may differentially moderate the relationship between metacognition and critical thinking. Third, most studies have focused on performance-based outcomes, with limited attention to critical thinking as a dispositional construct.

Clarifying whether cognitive load strengthens or weakens the metacognition and critical thinking relationships is therefore theoretically and practically important. A more precise understanding of this relationship can contribute to the development of more effective learning strategies and instructional designs. This issue is especially relevant in Indonesian higher education contexts, where instructional environments may impose substantial cognitive demands on students.

Based on these considerations, this study investigates whether intrinsic load, extraneous load, and germane load moderate the relationship between metacognition and critical thinking among Indonesian college students. By integrating metacognition, cognitive load theory, and critical thinking within a single empirical model, this study seeks to advance theoretical understanding of cognitive constraints on higher-order thinking and to provide practical implications for improving instructional design in Indonesian universities.

To address the gaps identified above, this study empirically examines whether metacognition predicts critical thinking among Indonesian college students and whether this relationship varies under different levels of cognitive load. Specifically, the study tests whether intrinsic load, extraneous load, and germane load moderate the relationship between metacognition and critical thinking. Given the mixed findings in prior research, no specific directional assumptions are imposed regarding the moderating effects of the cognitive load components.

2. METHOD

This study used a correlational quantitative design using moderated regression analysis to examine the direct relationship between metacognition and critical thinking and to test whether cognitive load functions as a moderating factor. Although the analysis was conducted within a path modeling framework, all variables were observed (non-latent) variables. This approach is appropriate for estimating predictive relationships and interaction effects among observed variables (Byrne, 2016; Kline, 2023). The analytical model included metacognition as an independent variable, critical thinking as a dependent variable, and three types of cognitive load, namely intrinsic, extraneous, and germane load, as moderating variables.

Participants consisted of 201 Indonesian college students recruited through purposive sampling. The inclusion criteria required participants to be active diploma or undergraduate students who had completed at least two academic semesters. This criterion was applied to ensure sufficient exposure to university-level coursework involving analytical reasoning, structured assignments, and reflective learning processes, which are conceptually relevant to metacognition and critical thinking.

The sample consisted of 111 females (55.2%) and 90 males (44.8%), with the mean age of 21.38 years ($SD=1.57$), ranging from 18 to 23 years. Participants were drawn from multiple regions of Indonesia, including Java (52.2%), Sumatra (41.8%), Kalimantan (2.0%), Sulawesi (2.5%), Bali (.5%), and Nusa Tenggara (1.0%). Although the sample was not nationally representative, the inclusion of participants from several regions increased geographic variability within the dataset.

Purposive sampling was chosen to ensure construct relevance rather than statistical representativeness. While this approach may limit generalizability, it strengthens internal validity by focusing on students with comparable academic exposure. This limitation is acknowledged.

Regarding statistical adequacy, the sample size exceeded general recommendations for regression-based moderation analysis (Kline, 2023). A post hoc power analysis indicated that a minimum of 153 participants was required to detect a small-to-moderate interaction effect ($F^2=.05$) with 0.80 power at $\alpha = .05$.

Therefore, the final sample of 201 participants provided adequate statistical power for the analyses conducted.

Three instruments were used in this study; all instruments employed Likert-type response scales, with higher scores indicating higher levels of the construct. Metacognition was measured using the Metacognitive Awareness Inventory (MAI), which has been adapted into Indonesian and validated in a prior study involving Indonesian students (Asfari et al., 2024). The MAI consists of two main dimensions: knowledge of cognition and regulation of cognition. In the present sample, internal consistency reliability was high ($\alpha = .941$), indicating strong internal consistency.

Cognitive load was measured using the Cognitive Load Scale adapted from Leppink et al. (2014), which measures three cognitive load components: intrinsic, extraneous, and germane load. The Indonesian adaptation followed standard translation procedures and cross-cultural adaptation procedures (Beaton et al., 2000), including forward translation, backward translation, and expert committee review. In the current sample, internal consistency coefficients were satisfactory: intrinsic load ($\alpha = .916$), extraneous load ($\alpha = .943$), and germane load ($\alpha = .914$).

Critical thinking was measured using the Critical Thinking Disposition Scale (CTDS) developed by Sosu (2013). It consists of two dimensions: critical openness and reflective skepticism. The Indonesian adaptation followed the translation and content validity procedure (Beaton et al., 2000). In the present sample, the instrument demonstrated acceptable internal consistency ($\alpha = .849$).

Data were collected online using Google Form. Participants provided informed consent before completing the questionnaire. The survey required approximately 15-20 minutes to complete. Participation was voluntary, and confidentiality of responses was ensured. All responses were screened for completeness prior to analysis, and no substantial missing data were observed.

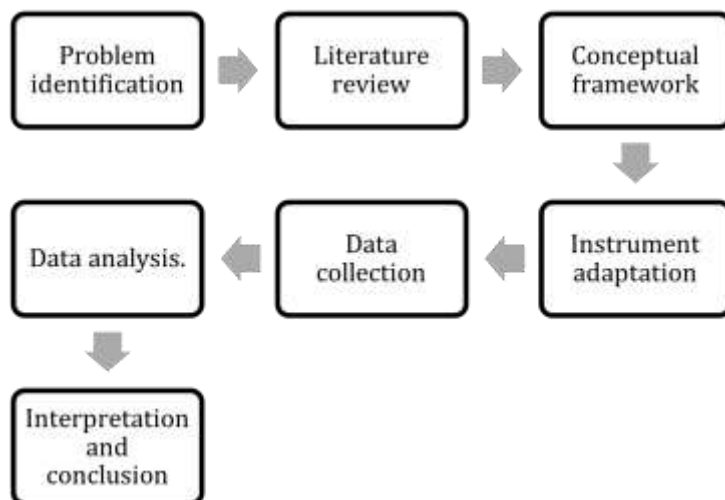


Figure 1. Research procedure

As illustrated in Figure 1 The search process consisted of a sequential stage, including problem identification, literature review, conceptual development, instrument adaptation, data collection, and data analysis.

Data were analyzed using the Classical Process Model module available in JASP. Moderation analyses were conducted to examine whether intrinsic load, extraneous load, and germane load moderated the relationship between metacognition and critical thinking. Each moderator was tested in a separate model to isolate its individual moderating effect and avoid interpretational confounding among interaction terms.

Prior to computing interaction terms, all continuous variables were mean-centered to reduce multicollinearity and improve the interpretability of regression coefficients (Aiken et al., 2010). Interaction terms were created by multiplying the centered predictor and moderator variables.

Multicollinearity diagnostics were conducted using linear regression analysis. Variance Inflation Factor (VIF) values ranged from 1.36 to 2.59, indicating acceptable levels of multicollinearity. Assumptions of linearity, homoscedasticity, and normality of residuals were evaluated before interpreting results. Statistical significance was evaluated at $p < .05$ using path coefficient estimates, standard errors, and 95% confidence intervals.

3. RESULTS

Descriptive statistics and Pearson correlation are presented in Table 1. All variables were analyzed using raw scores prior to centering for moderation analysis. The mean level of critical thinking was 46.61 (SD=5.02), while metacognition showed a mean of 121.50 (SD=13.98). Among the cognitive load components, germane load had the highest mean (M=31.13, SD=5.89), followed by intrinsic load (M=22.21, SD=5.42) and extraneous load (M=14.95, SD=8.43).

Table 1. Descriptive statistics and correlations

Var	M	SD	CT	MA	IL	EL	GL
CT	46.61	5.02	-				
MA	121.50	13.98	.686*	-			
IL	22.21	5.42	.355*	.489*	-		
EL	14.95	08.43	.063	.145*	.310*	-	
GL	31.18	5.89	.495*	.630*	.594*	.122	-

Var= Variable; CT=critical thinking; MA=metacognition, IL=intrinsic load; EL=extraneous load; GL=germane load. N=201. Values represent Pearson correlation coefficients. *p<.05. **p<.01. ***p<.001.

Correlation analysis indicated that metacognition showed a strong positive correlation with critical thinking ($r=.686$, $p<.001$), indicating that students with higher metacognitive awareness tended to demonstrate stronger critical thinking dispositions. This magnitude of correlation suggests substantial shared variance between reflective regulation processes and critical thinking disposition, consistent with theoretical models that metacognitive awareness enhances the development of critical thinking (Albab et al., 2020; Efklides, 2020; Veenman, 2012). Germane load was moderately correlated with critical thinking ($r=.495$, $p<.001$), whereas intrinsic load showed a smaller but significant correlation ($r=.355$, $p<.001$). In contrast, extraneous load showed no significant correlation ($r=.063$, $p=.376$).

Notably, metacognition was also strongly correlated with intrinsic load ($r=.489$, $p<.001$) and germane load ($r=.630$, $p<.001$),

indicating overlap between reflective regulation processes and perceived cognitive effort during learning (Leppink et al., 2014). These patterns justified the use of regression-based moderation analysis to disentangle shared variance beyond simple bivariate correlations.

Moderated regression analyses were conducted using mean-centered variables to reduce multicollinearity and improve the interpretability of interaction terms (Aiken et al., 2010). To examine whether cognitive load functions as a boundary condition in the relationship between metacognition and critical thinking, three separate moderated regression models were estimated. In each model, metacognition (mean-centered) was entered as the predictor, one component of cognitive load (mean-centered) was entered as the moderator, and their interaction term was included to test moderation. All analyses were conducted using the Classical Process Model in JASP. Multicollinearity diagnostics indicated acceptable levels (VIF values ranged from 1.36 to 2.59), suggesting that interaction terms did not inflate parameter estimates.

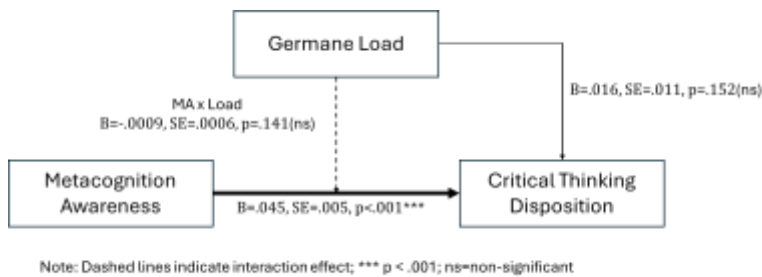
Across all models, metacognition consistently emerged as a significant predictor of critical thinking (all $p < .001$). The overall models explained approximately 47% to 50% of the variance in critical thinking ($R^2 \approx .47 - .50$), indicating a large effect size in behavioral research contexts. (Cohen, 2009). This indicates that nearly half of the variability in students' critical thinking disposition can be attributed to metacognitive awareness.

The inclusion of interaction terms did not produce significant changes in explained variance ($\Delta R^2 < .01$ in all cases), indicating that the moderating contribution of cognitive load components was negligible.

Table 2. Moderation analysis of cognitive load components

Predictor	Model 1		Model 2		Model 3	
	B (SE)	p	B (SE)	p	B (SE)	p
MA	.048 (.004)	<.001***	.049 (.004)	<.001***	.045 (.005)	<.001**
Load	.005 (.011)	.662	-.010 (.007)	.153	.016 (.011)	.152
MA × Load	-.00008 (.0006)	.901	.0008 (.0004)	.065	-.0009 (.0006)	.141

The regression coefficients for all three moderation models are presented in Table 2. Across Models 1 to 3, metacognition consistently demonstrated a strong positive effect on critical thinking ($B=.045$, $SE=.005$, $p<.001$). This effect remained stable regardless of which cognitive load component was included as a moderator. To provide a clearer structural interpretation of these findings, Figure 3. Conceptual Model and Empirical Extraneous Load as a Moderator



-4 presents the conceptual model and empirical results. The figure illustrates that metacognition has a strong direct effect on critical thinking, while intrinsic, extraneous, and germane load do not significantly moderate this association.

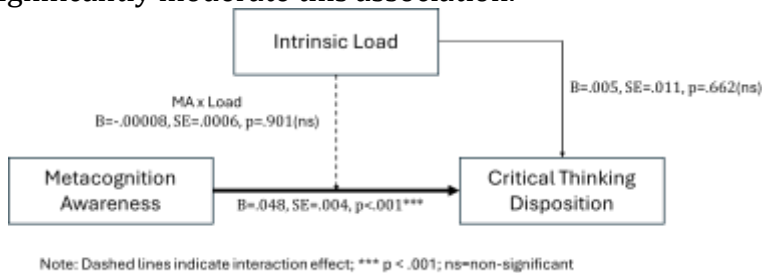


Figure 2. Conceptual Model And Empirical Intrinsic Load As Moderator

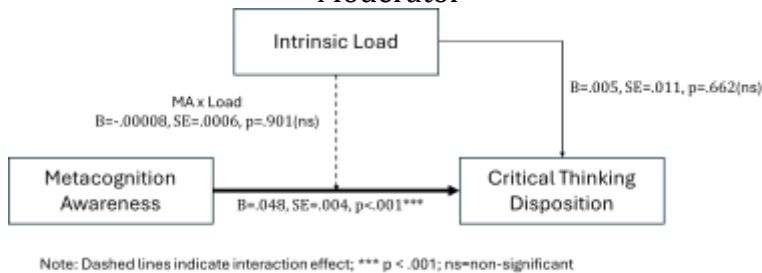


Figure 3. Conceptual Model and Empirical Extraneous Load as a Moderator

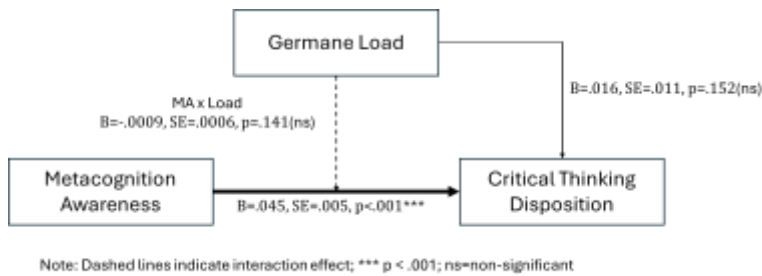


Figure 4. Conceptual Model And Empirical Generic Load As Moderator

In Figure 2, intrinsic load was tested as a moderator of the relationship between metacognition and critical thinking. Metacognition significantly predicted critical thinking ($B = .048, SE = .004, p < .001$). Intrinsic load did not show a significant direct effect ($B = .005, SE = .011, p = .662$). The interaction between metacognition and intrinsic load was not statistically significant ($B = -.00008, SE = .0006, p = .901$). These results indicate that intrinsic load did not significantly alter the strength of the correlation between metacognition and critical thinking.

In Figure 3, the extraneous load was examined as a moderator of the correlation between metacognition and critical thinking. Metacognition again significantly predicted critical thinking ($B = .049, SE = .004, p < .001$). Extraneous load was not a significant predictor ($B = -.010, SE = .007, p = .153$). The interaction between metacognition and extraneous load approached but did not reach statistical significance ($B = .0008, SE = .0004, p = .065$). Although the p -value was close to the conventional threshold, the confidence interval included zero ($CI = [-.00005, .002]$), indicating insufficient evidence for a moderating effect.

In Figure 4, Metacognition remained a significant predictor of critical thinking ($B = .045, SE = .005, p < .001$). Germane load did not show a significant direct effect ($B = .016, SE = .011, p = .152$). The interaction between metacognition and germane load was not statistically significant ($B = -.0009, SE = .0006, p = .141$).

4. DISCUSSION

This study provides empirical evidence that metacognition serves as a strong and stable predictor of critical thinking dispositions, while cognitive load does not significantly moderate

this relationship. As illustrated in **Error! Reference source not found**. The structural relationship between metacognition and critical thinking remains consistent across various levels of cognitive load, indicating that metacognitive processes operate independently of perceived cognitive constraints at the dispositional level.

The strong relationship between metacognition and critical thinking is consistent with a substantial body of prior research. Consistently, metacognitive awareness and regulation were identified as key determinants of higher-order thinking, including reflective skepticism and critical openness (Antonio & Prudente, 2021; Dwyer et al., 2014; Magno, 2010). The present findings extend this evidence by demonstrating that this association remains robust even when accounting for different types of cognitive load. This reinforces the conceptualization of metacognition as a core mechanism that enables students to plan, monitor, and evaluate their thinking processes, thereby facilitating more structured and evidence-based reasoning.

However, the absence of significant moderation effects suggests that the correlation between metacognition and critical thinking disposition remains stable across varying levels of perceived cognitive load. Rather than positioning Cognitive Load Theory as a competing framework, these findings suggest that cognitive load and metacognition operate at different levels of cognitive functioning. Metacognition reflects a high-level regulatory system that governs thinking processes across various contexts, whereas cognitive load reflects situational constraints that primarily affect processing efficiency during the performance of specific tasks (Sweller, 2011; Sweller et al., 2019). The dependent variable in this study, however, was critical thinking disposition, which reflects relatively stable tendencies towards reflective reasoning rather than immediate performance under experimentally manipulated task demands (Sosu, 2013). Because dispositional measures capture enduring cognitive orientation rather than situational processing efficiency, fluctuations in perceived cognitive load may not substantially alter the metacognitive contribution to critical thinking.

Several alternative explanations may account for the absence of moderation effects. First, cognitive load was measured using self-reported perceived effort rather than experimentally

controlled task manipulation. Although subjective rating scales are widely used in cognitive load research (Leppink et al., 2014; Paas et al., 2003) they capture learners' perceived mental effort rather than directly indexing underlying working memory processes. In particular, perceived germane effort may not precisely reflect objective schema construction processes (Kalyuga, 2011; Paas et al., 2003).

Second, the sample consisted of students within comparable academic environments, which may have limited variability in instructional design and task complexity, thereby reducing the likelihood of detecting interaction effects (Aguinis, 2004; Funder & Ozer, 2019). Moreover, cognitive load effects are more observable when task complexity is experimentally manipulated rather than naturally constrained within homogeneous instructional settings (Paas & Van Merriënboer, 2020).

Third, interaction effects are typically smaller in magnitude than main effects and require substantial statistical power to detect (Aiken et al., 2010). Although the sample size was adequate for moderation effects, very small moderation effects may remain undetected.

Finally, it is plausible that cognitive load exerts a stronger influence on performance-based critical thinking than on dispositional measures (Paas & Van Merriënboer, 2020; Sweller, 2020). If so, the absence of moderation in this study may reflect the conceptual distinction between cognitive performance and cognitive disposition. This finding requires theoretical clarification, as it diverges from studies that report cognitive load effects on learning and self-regulation processes. One critical explanation lies in the distinction between performance-based outcomes and dispositional constructs.

Taken together, these findings position metacognition as a stable and substantial predictor of critical thinking disposition among Indonesian college students. The results suggest that the reflective self-regulation processes operate consistently even under varying perceived cognitive demands (Dwyer et al., 2014; Kuhn, 2022; Veenman, 2012). In applied learning contexts, students with high metacognitive skills are able to effectively plan, monitor, and adapt their approaches to task completion (Li et al., 2024). These skills enable students to evaluate situations from multiple perspectives and make reasoned decisions (Amin et al., 2020;

Kusuma & Busyairi, 2023). This is consistent with the view that critical thinking skills depend not only on cognitive intelligence but also on an individual's capacity to manage their own thinking processes (Kozhevnikov et al., 2021).

From an instructional perspective, these findings suggest that efforts to enhance critical thinking should prioritize the development of metacognitive regulation rather than merely focusing on optimizing cognitive load conditions. Whilst reducing irrelevant cognitive load remains important, such strategies alone may be insufficient without simultaneous support for metacognitive processes. While optimizing instructional design remains important, cultivating students' capacity to plan, monitor, and evaluate their thinking appears to play a more decisive role in shaping higher-order cognitive disposition within the higher education context. These findings emphasize that metacognition abilities serve as a fundamental mechanism for critical thinking, suggesting that interventions targeting cognitive regulation may yield more consistent results than those focusing solely on cognitive load management.

This study contributes to the literature by clarifying the boundary conditions of Cognitive Load Theory in relation to higher-order thinking. Specifically, the findings demonstrate that cognitive load may not significantly influence dispositional outcomes, thereby highlighting the importance of distinguishing between state-dependent cognitive processes and stable cognitive tendencies. This distinction advances the theoretical understanding of how cognitive constraints interact with metacognitive regulation in educational contexts.

5. CONCLUSION

This study examined whether cognitive load functions as a boundary condition in the relationship between metacognition and critical thinking among Indonesian college students. The findings demonstrate that metacognitive awareness consistently predicts critical thinking disposition, accounting for a substantial proportion of variance across all models (Figure 4). This relationship remained stable even when intrinsic, extraneous, and germane cognitive load were included as moderators.

Contrary to the initial expectation, none of the cognitive load components significantly moderated the relationship between

metacognition and critical thinking. These findings suggest that the correlation between metacognitive awareness and critical thinking disposition remains stable across varying degrees of perceived cognitive demand. Rather than contradicting Cognitive Load Theory, the results refine its scope by indicating that cognitive load may exert a stronger influence on performance-based outcomes than on dispositional cognitive tendencies.

Several limitations should be acknowledged. The cross-sectional design limits causal inference, and cognitive load was assessed using self-reported measures rather than experimental manipulations of task complexity. Future research should incorporate experimental design and performance-based critical thinking measures to further examine how situational cognitive demands interact with metacognitive processes.

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