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Moderating Effects of Educational Level and Mathematical Competence on the Effectiveness of Cognitive Conflict Strategy: A Meta-Analysis

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ABSTRACT

This study aims to analyze the effectiveness of the cognitive conflict strategy in mathematics learning and to examine whether educational level and mathematical competence act as moderators in this strategy. A meta-analysis approach was conducted on 41 effect sizes. Data were analyzed using a random-effects model, with effect sizes calculated using Hedges' g. The data analysis was performed using the Comprehensive Meta-Analysis (CMA) software to ensure the accuracy of effect size calculations, heterogeneity tests, and moderator analyses. The results show that the cognitive conflict strategy has a significant effect ($g = 1.047$; $p < 0.05$). Additionally, mathematical competence was found to be a significant moderator ($p < 0.05$), with the highest effect sizes observed in conceptual understanding ($g = 1.712$) and critical thinking ($g = 1.355$). However, the educational level did not serve as a significant moderator ($p = 0.092$), indicating that the cognitive conflict strategy is beneficial across various educational levels. This study concludes that the cognitive conflict strategy is effective in enhancing mathematics learning, especially in conceptual understanding and critical thinking. Its novelty lies in identifying mathematical competence, not educational level, as a significant moderator. This implies that implementation should be adjusted based on the targeted competence. Future research may explore other potential moderators, including learner traits, instructional design, and technology use, to refine its application.

Keywords: Cognitive Conflict Strategy, Educational Level, Mathematical Competence, Mathematics Learning, Meta-Analysis

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Introduction

Cognitive conflict is a learning strategy aimed at creating cognitive disequilibrium in students' minds, encouraging them to restructure their existing concepts. This approach has been widely implemented in educational settings because it helps address misconceptions and enhance students' conceptual understanding (Chow & Treagust, 2013; Lee & Kwon, 2001; Ngicho et al., 2020). Cognitive conflict occurs when pupils come across material that deviates from what they already know, prompting them to assimilate or accommodate the new information to achieve cognitive equilibrium (Piaget, 1977). This strategy is effective in improving students' understanding and problem-solving skills in complex mathematical concepts by exposing them to situations that challenge their cognitive frameworks (Verawati & Afifah, 2018). Exposure to conflicting concepts can create awareness and lead students to a deeper understanding, even if it is not always directly identified as an effective problem-solving strategy (Tall & Vinner, 1981).

Cognitive conflict strategies are employed in mathematics education to present students with situations or problems that contradict their preexisting concepts, thereby challenging their initial understanding. This strategy is expected to encourage students' engagement in mathematics learning. Numerous research indicate that cognitive conflict might stimulate pupils to reassess their understanding and develop more precise notions (Kang et al., 2010; Rabab'ah, 2024; Widia et al., 2022). Research conducted by Chi & Wylie (2014) suggests that when students engage in interactions that stimulate discussion or debate, they are more likely to revise their understanding as a result of exchanging ideas. This indicates that when students are confronted with information inconsistent with their existing experiences, they can learn and explore to build better and more accurate understandings. This strategy also enhances students' problem-solving abilities (Fitri et al., 2019; Putra et al., 2020) as well as their critical thinking skills (Shandy, 2023; Sujana et al., 2019). These findings indicate that cognitive conflict strategies in mathematics education are effective for challenging initial understanding, encouraging concept revision, and improving conceptual understanding and problem-solving skills, making them a valuable approach to enhancing the quality of mathematics instruction.

Nonetheless, how well the cognitive conflict approach works can differ based on the learners' educational level and the type of mathematical competencies for development. Students at higher educational levels tend to possess better metacognitive skills, making them more capable of utilizing cognitive conflict to deepen their understanding (Brusilovsky & Millán, 2007; Zhou & Brown, 2017). Conversely, students at lower educational levels may require greater scaffolding to transform cognitive conflict into meaningful learning opportunities (Azevedo & Aleven, 2013; Palinscar & Brown, 2009). Moreover, the specific type of mathematical competence targeted in the learning process may serve as a moderating factor in determining the effectiveness of cognitive conflict strategies. The use of cognitive conflict strategies may influence different areas of mathematical competence in distinct ways, including the ability to solve problems, think critically, understand mathematical concepts, communicate ideas clearly, and reason about spatial information. A growing body of research has investigated how this strategy influences various aspects of students' mathematical development, highlighting its potential to enhance learning outcomes across multiple domains of mathematical proficiency. For example, applying cognitive conflict in educational settings can enhance students' ability to solve problems, with its impact varying based on the manner in which the approach is integrated into instruction (Ismaimuza, 2010; Pratiwi et al., 2022). It has also been found effective in enhancing students' conceptual understanding (Verawati & Afifah, 2018) and critical thinking skills (Shandy, 2023; Sujana et al., 2019).

Although cognitive conflict strategies have proven effective in improving mathematics learning outcomes, most studies have focused primarily on their direct impact without considering factors that may moderate their effectiveness. Some research still shows varying results regarding the extent to which cognitive conflict strategies enhance students' mathematical abilities across different educational levels. Furthermore, there is still a lack of studies specifically analyzing how certain mathematical competencies, including conceptual understanding, solving problems, and thinking critically, might serve as moderators of the strategy's effectiveness. Understanding these factors is crucial to ensure that cognitive conflict strategies can be optimally implemented across different educational levels and learning contexts.

This study addresses that gap by systematically quantifying and comparing the moderating effects of educational level and different types of mathematical competence. The novelty of this study lies in its dual focus: not only on the overall effectiveness of cognitive conflict strategies in mathematics learning, but also on the role of two key moderators that have not been jointly analyzed in previous research. Educational level and mathematical competence, as potential moderators, are examined through a meta-analysis approach, which allows for an empirical assessment of whether these variables significantly influence the outcomes under investigation. The findings of this study are expected to provide empirical insights for educators in designing cognitive conflict-based instruction that is tailored to students' cognitive profiles and educational contexts. This has important implications for implementing differentiated instruction in mathematics classrooms and for developing evidence-based pedagogical frameworks.

Methods

This research utilized the meta-analysis approach as a means to systematically investigate the extent to which educational level and types of mathematical competence influence, or moderate, the efficacy of cognitive conflict strategies in mathematics education. Retnawati et al. (2018) states that meta-analysis is a quantitative research strategy that entails the examination of quantitative information from prior studies to validate or invalidate the hypotheses presented in those studies. In addition, Borenstein et al. (2009) stated that meta-analysis is a quantitative synthesis method aimed at combining the results of various empirical studies to obtain stronger and more comprehensive conclusions. Thus, by synthesizing findings across multiple sources, this method allows for the generation of more robust, reliable, and generalizable conclusions. The stages of the meta-analysis in this study can be seen in Figure 1.

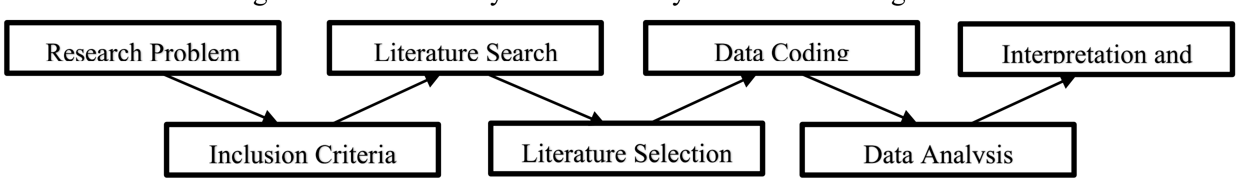

***Figure 1**. . The steps of meta-analysis* (Nugraha & Suparman, 2021)

A critical component of the meta-analysis approach entails doing a thorough and systematic review of the available literature to identify papers pertinent to the study aims. This process is fundamental to guaranteeing the reliability and validity of the findings. After collecting the initial pool of studies, the researchers implemented a rigorous screening procedure using a set of clearly defined inclusion and exclusion criteria. These criteria functioned as a standardized framework to evaluate the relevance, quality, and suitability of each study, ultimately determining whether or not a study qualified to be included in the final meta-analytic dataset. The inclusion criteria for this study were: (1) articles published between 2015 and 2025; (2) articles published in journals or conference proceedings; (3) the studies were conducted in Indonesia to maintain consistency in curriculum context, learning culture, and educational policies, all of which may influence the effectiveness of cognitive conflict strategies; (4) articles containing statistical data that could be utilized for meta-analysis; (5) articles with a research focus on cognitive conflict strategies in mathematics learning; and (6) articles that were accessible. The application of these inclusion criteria aims to ensure that data synthesis occurs within a controlled and contextually relevant boundary, thereby strengthening the internal validity of the findings. Nonetheless, the results retain their value as a foundational reference for further exploration and comparison within global educational contexts.

In this research, the data were collected by conducting an online search of previous research related to cognitive conflict strategies in mathematics learning, using the Publish or Perish software through Google Scholar and Scopus. The keywords used in the search were aligned with the research topic and included various synonyms and related terms. The keywords applied were ("cognitive conflict" OR "konflik kognitif") AND (mathematics OR matematika OR "math learning" OR "pembelajaran matematika"). Then, these articles were screened to ensure that only articles that met all inclusion requirements would be used in further analysis to produce good results (Onesimus Laia et al., 2025). The search procedure followed the PRISMA method, which ensures a comprehensive and systematic search strategy (Berlin & Golub, 2014; Page et al., 2021). The screening process was carried out by reviewing the titles and abstracts, followed by full-text screening (Hasanah & Suharso, 2023). The effect size data, based on Hedges' g (Thalheimer & Cook, 2002), were categorized into five groups: $ES < 0,15$ (ignored), $0,15 \leq ES < 0,4$ (low), $0,4 \leq ES < 0,75$ (moderate), $0,75 \leq ES < 1,1$ (high) dan $ES \geq 1,1$ (very high).

The data collected were analyzed using the Hedges' g approach, which is one of the standard techniques in meta-analysis to control for bias resulting from differences in sample sizes across studies (Hedges & Olkin, 1985; Khairunnisa et al., 2022). The analysis was performed employing both fixed-effect and random-effect models to validate the results and account for the variability across studies (Borenstein et al., 2009). Subsequently, a publication bias test was performed, as publication bias can threaten the validity of quantitative evidence in meta-analysis and should be carefully addressed by researchers (Nakagawa et al., 2022; Onesimus Laia & Dasari, 2025). Publication bias was evaluated using a funnel plot to examine the symmetry of the data distribution (Borenstein et al., 2009) and using the Duval and Tweedie's Trim and Fill method, which detects and corrects for publication bias by identifying asymmetry in the funnel plot and estimating and adding missing studies caused by such bias (S. Duval & Tweedie, 2000). In this study, after determining the effect size for each study and assessing publication bias, a heterogeneity test was conducted by checking the Q-statistic and p-value. Heterogeneity across studies was analyzed to assess the extent to which study results differ and to identify potential sources of variability (Higgins et al., 2003). Furthermore, a moderator analysis was carried out when heterogeneity was detected to determine whether educational level and/or mathematical competence moderated the effectiveness of the cognitive conflict strategy. All analyses were conducted utilizing the Comprehensive Meta-Analysis (CMA) software.

Results and Discussion

The initial phase of this investigation involved a meticulous screening process, in which all potential articles were carefully reviewed and evaluated according to a set of predetermined inclusion and exclusion criteria. This systematic approach ensured that only studies meeting the required standards and directly addressing the research focus were selected for further analysis. The articles incorporated in this meta-analysis were sourced from a diverse range of reputable national and international academic journals. A total of 1,228 studies were initially retrieved through the article search process. Among these, 16 duplicate studies were identified and removed, leaving 1,212 studies. An initial screening was then conducted by reviewing the titles and abstracts, resulting in the elimination of 959 studies that were not aligned with the research focus, leaving 253 studies. A further selection process was carried out based on the predetermined inclusion criteria. After this review, 229 studies were excluded: 93 studies involved populations outside the field of mathematics, 33 studies were inaccessible, 35 studies were sourced from repositories, and 68 studies lacked sufficient statistical data for further analysis. Consequently, 24 studies remained that met the inclusion criteria. From these 24 eligible studies, a total of 41 effect sizes related to the cognitive conflict strategy in mathematics learning were extracted for further analysis.

Subsequently, the data were categorized based on the research focus, namely by educational level and mathematical competence. The categorized data are presented in Table 1 below.

Table 1. *Categorical Data*

Category	Group	Frequency	Percentage (%)
Educational Level	Junior High School	18	43,9
	Senior High School	21	51,22
	Higher Education	2	4,88
Mathematical Competence	Critical Thinking	7	17,08
	Communication	6	14,64
	Spatial Literacy	4	9,75
	Conceptual Understandin	10	24,39
	Problem-Solving	10	24,39
	Representation	4	9,75

Following the initial data screening and selection process, the subsequent step involved conducting a publication bias assessment to ensure the reliability and objectivity of the meta-analysis results. This test is essential in evaluating whether the findings might be disproportionately influenced by studies that were more likely to be published due to the nature or significance of their results. As depicted in Figure 2, a funnel plot was used to visually represent the distribution of effect sizes derived from each individual study included in the meta-analysis. This graphical representation provides a clear and intuitive means of detecting asymmetries that may indicate the presence of publication bias. By analyzing the shape and spread of the funnel plot, researchers are better equipped to judge whether the effect sizes reported in the studies are distributed symmetrically and whether they can be interpreted as an accurate and unbiased reflection of the broader body of research available on the topic.

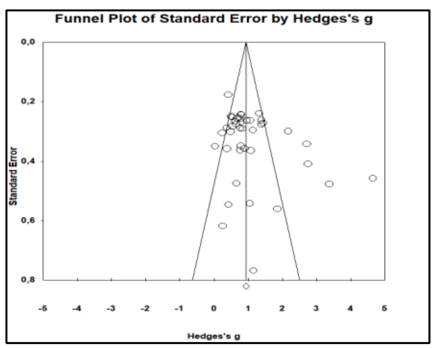

***Figure 2**. Funnel plot*

Figure 2 presents a funnel plot that visualizes how effect sizes are distributed across the studies incorporated in the meta-analysis. The plot reveals that the data points are fairly symmetrically distributed around the central effect size, which is a desirable outcome in meta-analytic research. Although there are a few points that slightly deviate, these deviations are not substantial enough to indicate a significant imbalance or serious bias. The analysis revealed no meaningful asymmetry in the data, suggesting that the presence of publication bias is minimal. (Egger et al., 1997; Sterne et al., 2011). To complement this visual analysis and to further validate the robustness of the data, the researchers employed the Duval and Tweedie's Trim and Fill method. This analytical approach is designed to account for and correct the possible effects of unpublished or missing studies resulting from publication bias. The findings, as summarized in Table 2, further substantiate the claim that the meta-analysis findings are both robust and largely unaffected by bias.

Table 2. *The Results of the Fill and Trim Test*

Model	Fixed Effects				Random Effects			Heterogeneity		
	Studies Trimmed	**Point estimate**	**Lower limit**	**Upper limit**	**Point estimate**	**Lower limit**	**Upper limit**	**Q-value**	**Df(Q)**	**P-value**
Observed values	0	0,942	0,850	1,034	1,046	0,827	1,266	216,464	40	0,000
Adjuste valuse		0,942	0,850	1,034	1,046	0,827	1,266			

Based on the data presented in Table 2, the findings from the Duval and Tweedie's Trim and Fill test demonstrate that none of the included studies required trimming. This finding indicates a lack of substantial evidence for publication bias affecting the integrity of the meta-analytic results. This conclusion is supported by the "Studies Trimmed" value, which is reported as 0. In other words, the effect size distribution across the analyzed studies appears to be sufficiently symmetrical, implying that the findings are not skewed by selective reporting or the absence of unpublished studies with non-significant results (Borenstein et al., 2009; S. Duval & Tweedie, 2000). The Fixed Effects model, based on both the observed and adjusted values, generated an effect size estimate of 0.942 (CI [0.850; 1.034]), whereas the Random Effects model produced a slightly higher estimate of 1.046 (CI [0.827; 1.266]). This convergence across models underscores the consistent impact of the cognitive conflict strategy (Higgins et al., 2003).

Table 2 also presents the results of the heterogeneity analysis, which yielded a Q-statistic of 216.464 and a highly significant p-value of 0.000, indicating substantial variability among the included studies. Since the p-value is below the conventional threshold of 0.05, the findings indicate substantial variation in effect sizes across the studies, thereby affirming the existence of heterogeneity. As a result, the random-effects model was deemed appropriate for estimating the overall effect size (Sedgwick, 2015). According to Ruppar (2020), a high degree of heterogeneity is not necessarily a cause for concern, as it can often be explained through subgroup or moderator analysis, which identifies sources of significant variation. Accordingly, additional analysis i\s required to assess whether educational level and types of mathematical competence serve as moderating factors in the effectiveness of cognitive conflict strategies.

Figure 3 displays a forest plot that visually summarizes the magnitude of each individual effect size along with the combined overall estimate derived from the analysis. This representation enhances clarity in interpreting both the strength and consistency of the relationships examined across the included studies. In addition, the figure presents the statistical significance test for the pooled effect, indicating whether the aggregated impact across studies reaches a significant level.

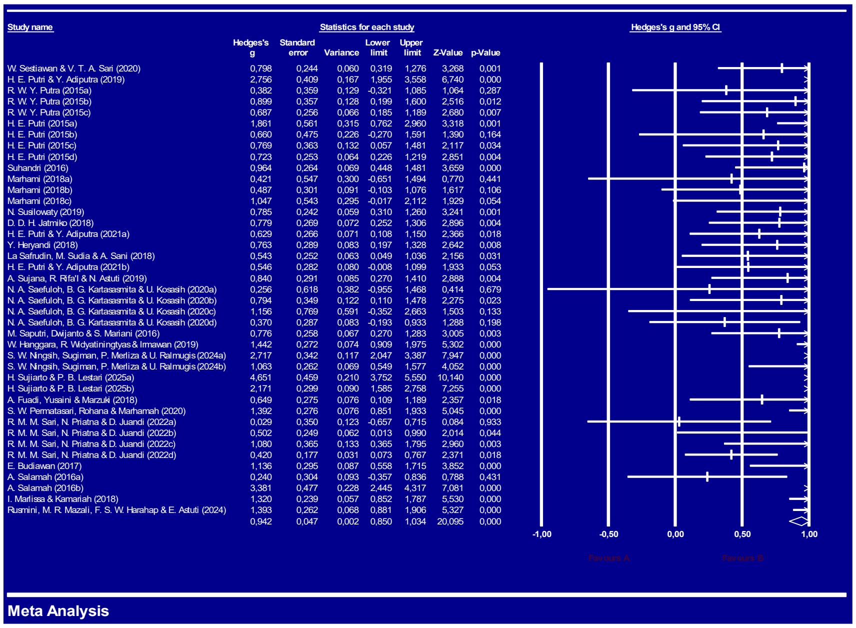

Figure 3. *Forest plot*

As illustrated in Figure 3, the distribution of effect sizes among the included studies shows variation in magnitude: one study demonstrates a negligible effect, four exhibit low effects, eleven report moderate effects, thirteen reflect high effects, and twelve reveal very high effects. Complementing this, Figure 3 presents the aggregated effect size derived from the random-effects model, calculated at 1.047, which reflects a strong impact. The figure further reports a p-value of 0.000 for the statistical test of the overall effect, which, being well below the 0.05 threshold, confirms the statistical significance of the cognitive conflict strategy's influence on mathematics learning. Hence, it can be concluded that this strategy exerts a notable and statistically significant effect in enhancing mathematics learning outcomes. These results align with the findings of D'Mello & Graesser (2012), who found that cognitive conflict can enhance conceptual understanding through reflective cognitive processes. Experiencing a cognitive disequilibrium between prior conceptions and newly encountered information compels students to initiate a reflective process of cognitive restructuring, thereby facilitating deeper and more enduring conceptual understanding. (D'Mello et al., 2014). Additionally, Kapur (2014) emphasized that exposing students to cognitive uncertainty or conflicts in mathematical understanding can significantly improve problem-solving skills and knowledge transfer.

The significance testing outcomes reveal considerable variability in effect sizes among the analyzed studies, pointing to the presence of heterogeneity. Consequently, it becomes imperative to undertake further moderator analyses to determine whether factors such as educational level and mathematical competence differentially influence the effectiveness of cognitive conflict-based interventions.

Table 3. *Results of the Moderator Analysis Based on Educational Level*

Educational Level	Effect size		Test of null (2-Tail)		Heterogeneity		
	Number of studies	Point estimate	Z- Value	P- Value	Q- value	Df	P- value
Junior High School	18	1,176	5,737	0,000	4,775	2	0,092
Senior High School	21	0,835	7,278	0,000			
Higher Education	2	2,038	2,995	0,003			

As presented in Table 3, the moderator variable pertaining to educational level is classified into three distinct categories. Within the junior high school category, the effect size is 1.176, indicating a very high effect; at the senior high school level, it is 0.835, indicating a high effect; and at the higher education level, it is 2.038, also indicating a very high effect. Furthermore, the heterogeneity analysis reported in Table 3 yields a p-value of 0.092, exceeding the conventional threshold of 0.05. This statistical outcome suggests that educational level does not exert a moderating influence on the effectiveness of the cognitive conflict strategy. According to constructivist theory, learning occurs through processes of assimilation and accommodation, which take place across all educational levels. Piaget argues that individuals actively construct knowledge based on their experiences, and cognitive conflict can arise at any stage of cognitive development without being restricted to a particular educational level (Piaget & Inhelder, 2000). Moreover, the effectiveness of an instructional strategy is not solely determined by the educational level but rather by the complexity of the tasks and the capacity of working memory (Kirschner et al., 2006). Children's cognitive development can progress optimally when they are exposed to a learning environment rich in challenges and stimulation (Maulana & Eliasan, 2024). Based on these considerations, it can be inferred that the effectiveness of the cognitive conflict strategy remains consistent across educational levels, indicating the absence of a moderating effect.

Table 4. *Results of the Moderator Analysis Based on Mathematical Competence*

Mathematical Competence	Effect size		Test of null (2-Tail)		Heterogeneity		
	Number of studies	Point estimate	Z-Value	P-Value	Q-value	Df	P-value
Critical Thinking	7	1,355	6,345	0,000	19,750	5	0,001
Communication	6	0,634	4,418	0,000			
Spatial Literacy	4	0,481	2,944	0,003			
Conceptual Understanding	10	1,712	5,020	0,000			
Problem-Solving	10	0,700	6,055	0,000			
Representation	4	0,868	4,133	0,000			

Based on Table 4, the moderator variable categorized by mathematical competencies is divided into six types. According to Table 4, the effect size for critical thinking skills is 1.355, indicating a very high effect; for mathematical communication, it is 0.634, indicating a moderate effect; for spatial literacy, it is 0.481, indicating a moderate effect; for conceptual understanding, it is 1.712, indicating a very high effect; for problem-solving, it is 0.7, indicating a moderate effect; and for mathematical representation, it is 0.868, indicating a high effect. Furthermore, the heterogeneity test presented in Table 4 yields a p-value of 0.001, which falls well below the standard significance threshold of 0.05. This finding indicates that mathematical competencies serve as a moderating factor for the effect of the cognitive conflict strategy.

The observed differences in the effectiveness of the cognitive conflict strategy across varying levels of mathematical competence suggest that this instructional approach yields greater impact when applied to specific domains of mathematical ability. The very high effect sizes for critical thinking skills and conceptual understanding suggest that the cognitive conflict strategy encourages students to reassess their understanding and resolve misconceptions, thereby enhancing both their conceptual understanding and critical thinking skills (Ismaimuza, 2010; Puspasari, 2017; Sholihah & Shanti, 2018; Sujana et al., 2019). The lower effect of the cognitive conflict strategy on mathematical communication and spatial literacy can be explained by the fact that these skills rely more heavily on social interaction and the use of visual aids, which are not the primary focus of the cognitive conflict strategy (Sfard, 2008). Meanwhile, problem-solving skills are often more effectively supported by problem-based approaches, such as Problem-Based Learning (PBL), which provide students with greater opportunities to apply concepts across various contexts (Kapur, 2016). The cognitive conflict strategy also shows a significant impact on mathematical representation skills. According to the theory of mathematical representation, a strong conceptual understanding enables students to represent ideas in multiple forms, such as graphs, tables, or visual models (R. Duval, 2017). The cognitive tension or conflict that arises when students encounter different representations can prompt them to restructure their understanding, supporting the development of stronger and more flexible systems of representation, which is a fundamental goal of mathematics learning (Goldin & Kaput, 1996).

The results of this study reveal that mathematical competence significantly moderates the effectiveness of cognitive conflict strategies, while educational level does not. This suggests that the success of such strategies is more dependent on the nature of the cognitive demands rather than the students' grade level. Therefore, instructional design should take into account students' mathematical competencies, particularly their level of conceptual understanding and critical thinking ability. These findings support the implementation of differentiated instruction in mathematics classrooms, where tasks and cognitive conflict stimuli can be adjusted according to students' readiness and competence levels. Such differentiation ensures that the conflict introduced is productive and cognitively accessible, maximizing its impact on learning outcomes.

Conclusion

Findings from this meta-analysis underscore the substantial impact of the cognitive conflict strategy on mathematics learning, as evidenced by a high effect size in promoting both conceptual understanding and critical thinking skills. Moreover, mathematical competence was found to be a moderating factor influencing the efficacy of the cognitive conflict strategy, with the strategy being more effective in improving conceptual understanding and critical thinking compared to other competencies such as mathematical communication, spatial literacy, problem-solving, and mathematical representation. Conversely, educational level was not identified as a significant moderator, suggesting that the cognitive conflict strategy provides relatively consistent benefits across different educational stages.

Although this study yielded significant results, it has several limitations. A key limitation of this study is the relatively limited sample size, which may constrain the broader applicability of the results. Furthermore, discrepancies in the research methodologies employed across the analyzed studies could potentially impact the observed effectiveness of the cognitive conflict strategy. This study also focused solely on two main moderating factors, namely educational level and mathematical competence, without considering other potential factors such as students' learning styles, teachers' instructional methods, or the cultural context of learning. In addition, this study is based solely on research conducted in Indonesia, which may limit the generalizability of the findings. Educational policies, learning cultures, teacher preparedness, and curriculum frameworks vary significantly across countries and may influence the effectiveness of cognitive conflict strategies. Therefore, future research is recommended to include a broader and cross-national scope to validate and extend the applicability of the findings globally. Further studies should also explore other potential moderating factors, such as student characteristics, instructional design, and the integration of technology in mathematics learning, in order to optimize the use of cognitive conflict strategies in diverse educational contexts.

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References

Azevedo, R., & Aleven, V. (2013). Metacognition and Learning Technologies: An Overview of Current Interdisciplinary Research. In *Springer International Handbooks of Education* (Vol. 28, pp. 1–16). Springer Nature. https://doi.org/10.1007/978-1-4419-5546-3_1

Berlin, J. A., & Golub, R. M. (2014). Meta-analysis as evidence: Building a better pyramid. *Jama*, *312*(6), 603–605. https://doi.org/10.1001/jama.2014.8167

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). Introduction to Meta-Analysis. In *Principles and Practice of Clinical Trials*. Wiley. https://doi.org/10.1002/9780470743386

Brusilovsky, P., & Millán, E. (2007). User Models for Adaptive Hypermedia and Adaptive Educational Systems. In *The Adaptive Web* (pp. 3–53). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-72079-9_1

Chi, M. T. H., & Wylie, R. (2014). The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes. *Educational Psychologist*, *49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Chow, T.-C. F., & Treagust, D. F. (2013). An Intervention Study Using Cognitive Conflict to Foster Conceptual Change. *Journal of Science and Mathematics*, *36*(1), 44–64.

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. *Learning and Instruction*, *22*(2), 145–157. https://doi.org/10.1016/j.learninstruc.2011.10.001
D'Mello, S., Lehman, B., Pekrun, R., & Graesser, A. (2014). Confusion can be beneficial for learning. *Learning and Instruction*, *29*, 153–170. https://doi.org/10.1016/j.learninstruc.2012.05.003
Duval, R. (2017). *Understanding the Mathematical Way of Thinking – The Registers of Semiotic Representations*. Springer International Publishing. https://doi.org/10.1007/978-3-319-56910-9
Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*(2), 455–463. https://doi.org/10.1111/j.0006-341X.2000.00455.x
Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal*, *315*(7109), 629–634. https://doi.org/10.1136/bmj.315.7109.629
Fitri, S., Syahputra, E., & Syahputra, H. (2019). Blended Learning Rotation Model Of Cognitive Conflict Strategy To Improve Mathematical Resilience In High School Students. *Article in International Journal of Scientific & Technology Research*, *8*. www.ijstr.org
Goldin, G., & Kaput, J. (1996). *A joint perspective on the idea of representation in learning and doing mathematics* (pp. 397–430).
Hasanah, M., & Suharso, A. (2023). Algoritma Haversine pada Sistem Informasi Geografis: Tinjauan Literatur Sistematis. *Nuansa Informatika*, *17*(2), 135–143. https://doi.org/10.25134/ilkom.v17i2.10
Hedges, L. V, & Olkin, I. (1985). *Statistical Methods for Engineers*. Academic Pres, Inc: New york.
Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. In *British Medical Journal* (Vol. 327, Issue 7414, pp. 557–560). https://doi.org/10.1136/bmj.327.7414.557
Ismaimuza, D. (2010). Pengaruh Pembelajaran Berbasis Masalah Dengan Strategi Konflik Kognitif Terhadap Kemampuan Berpikir Kritis Matematis Dan Sikap Siswa SMP. *Jurnal Pendidikan Matematika*, *4*(1).
Kang, H., Scharmann, L. C., Kang, S., & Noh, T. (2010). Cognitive conflict and situational interest as factors influencing conceptual change. *International Journal of Environmental and Science Education*, *5*(4), 383–405. http://www.ijese.com/
Kapur, M. (2014). Productive failure in learning math. *Cognitive Science*, *38*(5), 1008–1022. https://doi.org/10.1111/cogs.12107
Kapur, M. (2016). Examining Productive Failure, Productive Success, Unproductive Failure, and Unproductive Success in Learning. *Educational Psychologist*, *51*(2), 289–299. https://doi.org/10.1080/00461520.2016.1155457
Khairunnisa, K., Sari, F. F., Anggelena, M., Agustina, D., & Nursa'adah, E. (2022). Penggunaan Effect Size Sebagai Mediasi dalam Koreksi Efek Suatu Penelitian. *Jurnal Pendidikan Matematika (Judika Education)*, *5*(2), 138–151. https://doi.org/10.31539/judika.v5i2.4802
Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, *41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1
Lee, G., & Kwon, J. (2001). What Do We Know about Students' Cognitive Conflict in Science Classroom : A Theoretical Model of Cognitive Conflict Process. *AETS Annual Meeting*, 309–325.
Maulana, R., & Eliasan, E. I. (2024). Eksplorasi Ciri Khas dan Tugas Perkembangan Anak Usia Dini (2-6 Tahun): Implikasi Fisik, Kognitif, dan Sosio-Emosi dalam Pendidikan dan Pengasuhan. *EDUCATIONAL : Jurnal Inovasi Pendidikan & Pengajaran*, *4*(4), 239–252. https://doi.org/10.51878/educational.v4i4.3404
Nakagawa, S., Lagisz, M., Jennions, M. D., Koricheva, J., Noble, D. W. A., Parker, T. H., Sánchez-Tójar, A., Yang, Y., & O'Dea, R. E. (2022). Methods for testing publication bias in ecological and evolutionary meta-analyses. *Methods in Ecology and Evolution*, *13*(1), 4–21.

https://doi.org/10.1111/2041-210X.13724
Ngicho, D. O., Karuku, S., & King'endo, M. (2020). Manifestations and meanings of cognitive conflict among mathematics students in Embu, Kenya. *Educational Research and Reviews*, *15*(11), 690–699. https://doi.org/10.5897/ERR2020.4061
Nugraha, T., & Suparman, S. (2021). Heterogeneity of Indonesian primary school students' mathematical critical thinking skills through problem-based learning: A meta-analysis. *Al-Jabar : Jurnal Pendidikan Matematika*, *12*(2), 315–328. https://doi.org/10.24042/ajpm.v12i2.9645
Onesimus Laia, H., & Dasari, D. (2025). Meta-Analysis: Effectiveness of Reciprocal Teaching Model on Mathematics Learning Outcomes. *Mathline : Jurnal Matematika Dan Pendidikan Matematika*, *10*(1), 29–43. https://doi.org/10.31943/mathline.v10i1.688
Onesimus Laia, H., Martadiputra, B. A. P., & Dahlan, J. A. (2025). The Effect of Logical-Mathematical Intelligence on Mathematics Learning and Moderator Analysis : A Meta- Analysis. *Al-Jabar: Jurnal Pendidikan Matematika*, *16*(01), 129–149. https://doi.org/10.24042/ajpm.v16i1.25539
Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, *372*. https://doi.org/10.1136/bmj.n71
Palinscar, A. S., & Brown, A. L. (2009). Reciprocal Teaching of Comprehension-Fostering and Comprehension Monitoring Activities. *Cognition and Instruction*, *1*(2), 117–175. https://doi.org/10.1207/s1532690xci0102
Piaget, J. (1977). *The Development of Thought. Equilibration of Cognitive Structures*. Oxford: Basil Blackwell.
Piaget, J., & Inhelder, B. (2000). *The Psychology of the Child*. Basic Books, 1290 Avenue of the Americas, New York, NY 10104. https://doi.org/10.2307/j.ctv19fvxpz.8
Pratiwi, E., Nanna, A. W. I., & Wulandari, A. E. (2022). Peran Strategi Konflik Kognitif pada Proses Penyeleaian Masalah Geometri. *SIGMA*, *8*(1), 68. https://doi.org/10.53712/sigma.v8i1.1743
Puspasari, R. (2017). Strategi Konflik Kognitif (Cognitive Conflict) dalam Mengatasi Miskonsepsi Siswa. *JP2M (Jurnal Pendidikan Dan Pembelajaran Matematika)*, *3*(1), 1. https://doi.org/10.29100/jp2m.v3i1.285
Putra, R., Fauzan, A., & Habibi, M. (2020). The Impact of Cognitive Conflict Based Learning Tools on Students` Mathematical Problem Solving Ability. *International Journal of Educational Dynamics*, *2*(1), 209–218. https://doi.org/10.24036/ijeds.v2i1.247
Rabab'ah, Y. (2024). Effect of Cognitive Conflict Strategy and Motivation on Conceptual Change in Algebra. *International Journal of Academic Research in Progressive Education and Development*, *13*(1). https://doi.org/10.6007/IJARPED/v13-i1/21207
Retnawati, H., Apino, E., Kartianom, Djidu, H., & Anazifa, R. D. (2018). Pengantar Analisis Meta. In *Yogyakarta : Parama Publishing* (Issue July).
Ruppar, T. (2020). Meta-analysis: How to quantify and explain heterogeneity? *European Journal of Cardiovascular Nursing*, *19*(7), 646–652. https://doi.org/10.1177/1474515120944014
Sedgwick, P. (2015). Meta-analyses: what is heterogeneity? *BMJ*, *350*(mar16 1), h1435–h1435. https://doi.org/10.1136/bmj.h1435
Sfard, A. (2008). *Thinking as Communicating: Human development, the growth of discourses, and mathematizing.* Cambridge University Press. https://doi.org/10.1017/CBO9780511499944
Shandy, A. N. (2023). Kemampuan Berpikir Kritis dan Kepercayaan Diri Siswa pada Pembelajaran dengan Strategi Konflik Kognitif. *Jurnal Ilmu Pendidikan Dan Psikologi (JIPP)*, *1*(4), 176–183. https://doi.org/10.61116/jipp.v1i4.259
Sholihah, D. A., & Shanti, W. N. (2018). Pembelajaran Konflik Kognitif Untuk Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa. *UNION: Jurnal Ilmiah Pendidikan Matematika*, *6*(1), 71–82. https://doi.org/10.30738/.v6i1.1999

Sterne, J. A. C., Sutton, A. J., Ioannidis, J. P. A., Terrin, N., Jones, D. R., Lau, J., Carpenter, J., Rücker, G., Harbord, R. M., Schmid, C. H., Tetzlaff, J., Deeks, J. J., Peters, J., Macaskill, P., Schwarzer, G., Duval, S., Altman, D. G., Moher, D., & Higgins, J. P. T. (2011). Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ (Online)*, *343*(7818), 1–8. https://doi.org/10.1136/bmj.d4002

Sujana, A., Rifa'i, R., & Astuti, N. (2019). Penerapan Strategi Konflik Kognitif untuk Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa SMP. *Jurnal Penelitian Dan Pembelajaran Matematika*, *12*(1). https://doi.org/10.30870/jppm.v12i1.4864

Tall, D., & Vinner, S. (1981). *Concept Image and Concept Definition in Mathematics with Particular Reference to Limits and Continuity*.

Thalheimer, W., & Cook, S. (2002). How to calculate effect sizes from published research. *Work-Learning Research*, *1*(August), 1–9. www.work-learning.com

Verawati, N. N. S. P., & Afifah, G. (2018). Efek Penggunaan Strategi Konflik Kognitif terhadap Hasil Belajar Kognitif Siswa. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *6*(2), 113. https://doi.org/10.33394/j-ps.v6i2.1081

Widia, W., Suhirman, S., Suhardi, M., Prayogi, S., Yamin, M., Salahuddin, M., Haryanto, L., Ewisahrani, E., E Nursa'ban, E. N., Ilyas, I., & Mujitahid, M. (2022). The Effect of Cognitive Conflict Strategies on Students' Cognitive Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 388–392. https://doi.org/10.29303/jppipa.v8i1.1308

Zhou, M., & Brown, D. (2017). *Educational Learning Theory*. Education Open Textbooks. https://doi.org/10.4324/9780203062920-11