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Enhancing Creative Thinking Abilities and Mathematical Thinking Dispositions in Elementary Students

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Abstract
Creative thinking abilities and mathematical thinking dispositions represent critical competencies in elementary mathematics education, yet limited research examines their simultaneous development through targeted pedagogical interventions. This study investigated differences in creative thinking abilities and mathematical thinking dispositions between elementary students receiving differentiated instructional treatments. A quasi-experimental design with non-equivalent control groups was employed, involving 60 fifth-grade students from SD Negeri Sentul 1, divided into experimental (n=30) and control (n=30) groups. Creative thinking ability was measured using an essay test based on Guilford's four-dimensional framework (fluency, flexibility, originality, elaboration), while mathematical thinking disposition was assessed through a four-point Likert scale questionnaire encompassing curiosity, perseverance, open-mindedness, self-confidence, and reflectivity. Data were analyzed using independent samples t-tests following normality and homogeneity assumption testing. Significant differences emerged between groups across all measured constructs ($p<0.05$). The experimental group demonstrated superior creative thinking ability ($M=82.6$ vs. $M=73.9$, Cohen's $d=1.18$) and more positive mathematical thinking disposition ($M=3.42$ vs. $M=2.94$, Cohen's $d=1.06$). Elaboration showed the largest creative thinking difference (9.6 points), while open-mindedness exhibited the greatest dispositional improvement (0.53 points). Findings provide empirical evidence that targeted instructional approaches can simultaneously enhance cognitive abilities and affective dispositions in mathematics learning. The synergistic relationship between creative thinking and positive dispositions challenges traditional pedagogical models that address these dimensions separately. Results support implementing learning environments that encourage exploration, multiple solution strategies, and reflective practices to develop both mathematical competencies and positive attitudes toward mathematics in elementary education.

INTRODUCTION

Mathematics education serves as a cornerstone for developing students' logical, systematic, and critical thinking capabilities from the earliest stages of formal education. At the elementary level, mathematical competency extends beyond mere procedural knowledge to encompass the cultivation of higher-order cognitive skills essential for navigating complex real-world challenges. Beaty et al. (2016) define creativity as our fundamental ability to generate novel and useful ideas, representing a foundational skill that enables unprecedented capacity for problem-solving and innovation. Within this educational framework, two interconnected psychological constructs have emerged as particularly significant: creative thinking abilities and mathematical thinking dispositions. These competencies represent fundamental aspects of mathematical learning that require systematic development through purposeful and evidence-based pedagogical approaches (Putri & Fitria, 2020).

Creative thinking in mathematics encompasses students' capacity to generate diverse solutions, develop innovative problem-solving strategies, and express mathematical ideas in original ways. Guilford (1986) conceptualized creativity as divergent thinking, encompassing four essential components: fluency, flexibility, originality, and elaboration. This multidimensional construct has gained recognition as a critical 21st-century competency, with research demonstrating its fundamental role in enhancing mathematical problem-solving capabilities (Trilling & Fadel, 2009; Hwang et al., 2007). Sternberg (1999) further emphasizes that creativity enables unprecedented capacity for problem-solving and innovation, constituting a vital component of adaptive success across multiple domains including industrial design and scientific research (Kaufman & Sternberg, 2010).

Contemporary neuroscientific perspectives suggest that creative thinking emerges from the dynamic interaction of ordinary cognitive processes rather than relying on specialized mechanisms (Abraham & Windmann, 2007; Smith et al., 1995). This involves complex coordination of memory-based processing, cognitive control, attention regulation, mental imagery, and reasoning capabilities (Benedek & Fink, 2019; Gray et al., 2019). Research demonstrates that higher-quality creative thought can be attributed to enhanced performance in cognitive operations such as semantic retrieval and association (Kenett et al., 2018), working memory and cognitive flexibility (Benedek et al., 2014; Dreu et al., 2011), focused and flexible attention (Nusbaum & Silvia, 2011; Zabelina & Robinson, 2010), mental imagery capabilities (LeBoutillier & Marks, 2003), and analogical reasoning (Green et al., 2012). Moreover, creativity manifests when students encounter problem-solving situations that require divergent approaches, often revealing itself through distinctive personality characteristics, attitudes, and behavioral patterns (Awang & Ramly, 2008; Cropley, 2000).

Despite its recognized importance, empirical evidence reveals concerning deficiencies in elementary students' creative thinking capabilities. Many students demonstrate restricted problem-solving approaches, relying heavily on memorized procedures and exhibiting limited capacity to elaborate upon their solutions. This phenomenon particularly emerges in educational contexts where traditional instructional methods emphasize repetitive practice and routine problem-solving, potentially depriving students of opportunities for divergent thinking. Such patterns align with findings from Sari and Mustika (2021), who documented that most elementary students solve mathematical problems exclusively through teacher-demonstrated methods without exploring alternative strategies. This indicates that current mathematics instruction remains predominantly procedural, failing to nurture students' creative thinking potential effectively.

Complementing cognitive abilities, affective dimensions play equally crucial roles in mathematical learning outcomes. Mathematical thinking disposition represents students' internal orientations and attitudes toward mathematical activities, encompassing curiosity, perseverance, openness to novel ideas, intellectual risk-taking, and confidence in mathematical reasoning (Sumarmo, 2020). These dispositions constitute unique psychological constructs that significantly influence how students approach mathematical challenges, respond to difficulties, and maintain engagement in learning processes (Young et al., 2019; Berry et al., 2011). Martin (2000) emphasizes that mathematical disposition formation involves students' beliefs about their ability to perform mathematics, the significance of mathematical knowledge, opportunities or barriers to enter mathematics fields, and the motivation and persistence needed to obtain mathematical knowledge.

Research demonstrates that students with positive mathematical dispositions exhibit greater persistence when confronting complex problems, while those with negative dispositions tend toward avoidance and premature abandonment of challenging tasks (Dewi & Nugraheni, 2019). The development of mathematical dispositions occurs concurrently with other psychological constructs throughout elementary and middle school years, creating complex interrelationships that significantly affect learning outcomes (Leonard & Martin, 2013; McGee, 2013). Cobb & Hodge (2011) conceptualize mathematical identity as the ability of students and others to perceive the student as a mathematics person, highlighting the social dimension of mathematical disposition development. Furthermore, students must navigate intersections of multiple identities including racial, disciplinary,

and academic identities within mathematics classrooms (Varelas et al., 2012). Several empirical studies have documented statistically significant relationships between mathematical identity and learning outcomes, particularly demonstrating positive effects that warrant continued investigation (Young, 2018; Spencer, 2010; Gabriel et al., 2017).

The challenge confronting contemporary mathematics education involves creating instructional environments that simultaneously foster both cognitive and affective dimensions. Educational practices that emphasize test score improvement through knowledge acquisition and repetitive thinking may inadvertently limit students' opportunities for divergent thinking, potentially restraining creativity development. This concern parallels observations from educational contexts where students become accustomed to solving only routine problems without developing independent thinking capabilities. Preliminary observations at SD Negeri Sentul 1 revealed that students predominantly employ teacher-prescribed solution patterns without exploring alternative approaches, display passive learning behaviors, demonstrate reluctance to pose questions, and exhibit limited confidence in expressing mathematical ideas during classroom discussions. These observations suggest that both creative thinking abilities and mathematical thinking dispositions require more intensive developmental attention through instructional approaches that prioritize meaningful learning over mechanical skill acquisition.

Research investigating the relationship between creative thinking abilities and mathematical thinking dispositions has yielded compelling evidence of their interconnectedness. Yuliani et al. (2022) documented positive correlations between these constructs, demonstrating that students who engage in flexible, open-minded thinking also exhibit more active, reflective, and confident attitudes throughout mathematical learning processes. Jauk (2019) and Khalil et al. (2019) emphasize that creativity represents a central component of healthy cognitive functioning, requiring complex interactions between biological and environmental factors. This finding underscores the necessity of examining both constructs simultaneously to obtain comprehensive understanding of students' mathematical learning profiles, particularly considering that creative thinking requires the combined function of multiple cognitive processes working in coordination.

Quasi-experimental research methodology provides an appropriate framework for evaluating the extent to which targeted interventions can enhance students' cognitive abilities and affective dispositions. This design enables researchers to compare learning outcomes between different instructional approaches while accommodating the practical constraints inherent in educational settings. Such research offers realistic insights into classroom implementation effects on students' cognitive and affective development (Hakim & Puspita, 2021).

Given the critical importance of developing both creative thinking abilities and positive mathematical dispositions in elementary students, and considering the limited research examining their simultaneous development through specific instructional approaches, this study addresses a significant gap in the literature. The investigation aims to analyze differences in creative thinking abilities and mathematical thinking dispositions between elementary students receiving different instructional treatments. By examining these constructs concurrently, this research contributes to understanding how educational interventions can effectively support both cognitive skill development and positive attitude formation in mathematics learning.

The significance of this research extends beyond immediate educational outcomes to encompass broader implications for mathematics education reform. Understanding how instructional approaches influence both thinking abilities and learning dispositions provides essential insights for developing more effective pedagogical strategies that prepare students for mathematical success throughout their academic careers and beyond. Furthermore, this investigation contributes to the growing body of evidence supporting the integration of cognitive and affective considerations in mathematics education research and practice.

METHOD

This study employed a quantitative approach utilizing a quasi-experimental design with a non-equivalent control group structure. The quasi-experimental methodology was selected as the most appropriate research framework given the practical constraints of educational settings, where random assignment of participants is often unfeasible while maintaining the integrity of existing classroom structures. This design enables systematic comparison between experimental and control conditions while accommodating the natural educational environment, thereby enhancing the ecological validity of the findings.

The research population comprised all fifth-grade students enrolled at SD Negeri Sentul 1, Tangerang Regency, during the 2024/2025 academic year. Sample selection was conducted through purposive sampling methodology, employing specific criteria to ensure comparability between groups. Two intact fifth-grade classes were selected based on their relatively equivalent enrollment numbers and comparable academic performance profiles as determined by prior assessment records. Class V-A, consisting of 30 students, was designated as the experimental group, while Class V-B, also comprising 30 students, served as the control group. This sample size was determined to provide adequate statistical power for detecting meaningful differences between groups while maintaining practical feasibility for the research context.

Data collection was facilitated through two primary research instruments, each designed to measure distinct but complementary constructs. Mathematical creative thinking ability was assessed using a researcher-developed essay test incorporating Guilford's four-dimensional framework of creativity: fluency, flexibility, originality, and elaboration. The instrument consisted of open-ended mathematical problems requiring students to demonstrate multiple solution strategies, innovative approaches, and detailed explanations of their reasoning processes. Mathematical thinking disposition was measured through a structured questionnaire employing a four-point Likert scale format, designed to capture students' attitudinal orientations toward mathematical activities across five key dimensions: curiosity, perseverance, open-mindedness, self-confidence, and reflectivity.

Both instruments underwent rigorous validation procedures to ensure psychometric adequacy. Content validity was established through expert judgment involving mathematics education specialists who evaluated item relevance, clarity, and alignment with theoretical constructs. The reliability of the questionnaire was assessed using Cronbach's alpha coefficient, yielding values exceeding 0.70 for all subscales, indicating acceptable internal consistency. The essay test reliability was established through inter-rater agreement protocols involving multiple trained evaluators.

The data collection procedure was implemented over a three-week instructional period, during which both groups received instruction on identical mathematical content but through differentiated pedagogical approaches. Baseline equivalence between groups was verified through pretest administration prior to intervention implementation. Following the completion of the instructional intervention, post-test measurements were conducted to assess mathematical creative thinking abilities, while the disposition questionnaire was administered immediately thereafter to minimize potential confounding effects.

Data analysis proceeded through multiple sequential stages to ensure analytical rigor. Initial analyses included assessment of data distribution normality using the Shapiro-Wilk test and evaluation of variance homogeneity through Levene's test. These preliminary assessments verified the appropriateness of parametric statistical procedures for subsequent hypothesis testing. Primary analyses employed independent samples t-tests to examine between-group differences in both creative thinking abilities and mathematical thinking dispositions. Statistical significance was evaluated at the $\alpha = 0.05$ level, with effect sizes calculated to determine practical significance of observed differences.

Throughout the research process, ethical considerations were rigorously maintained in accordance with educational research standards. Institutional approval was secured from school administration, and informed consent was obtained from all participants and their parents or

guardians. Data confidentiality and participant anonymity were preserved through systematic coding procedures, ensuring that individual identification was not possible during analysis or reporting phases.

RESULT AND DISCUSSION

Results

The analysis of data collected from 60 fifth-grade students at SD Negeri Sentul 1 revealed significant differences between experimental and control groups across both measured constructs. Prior to presenting the primary findings, preliminary analyses confirmed that all data met the assumptions for parametric testing. The Shapiro-Wilk test indicated normal distribution for both creative thinking ability scores ($W = 0.976$, $p = 0.342$) and mathematical thinking disposition scores ($W = 0.981$, $p = 0.456$). Additionally, Levene's test demonstrated homogeneity of variance between groups for creative thinking ability ($F = 1.234$, $p = 0.271$) and mathematical thinking disposition ($F = 0.987$, $p = 0.325$).

The assessment of mathematical creative thinking ability demonstrated substantial differences between the experimental and control groups across all measured dimensions. Table 1 presents the mean scores for each indicator of creative thinking ability, revealing consistently higher performance in the experimental group.

Table 1. Mean Scores of Mathematical Creative Thinking Ability by Indicator

Indicator	Experimental Group	Control Group	t-value	p-value
Fluency	83.2	75.4	3.45	0.001
Flexibility	81.5	73.8	3.12	0.003
Originality	79.7	70.2	3.78	0.000
Elaboration	86.1	76.5	4.21	0.000
Overall	82.6	73.9	4.56	0.000

The data in Table 1 indicates that students in the experimental group achieved significantly higher scores across all four dimensions of creative thinking. The elaboration indicator showed the largest difference between groups (9.6 points), followed by originality (9.5 points), fluency (7.8 points), and flexibility (7.7 points). The overall creative thinking ability score demonstrated a substantial difference of 8.7 points between groups ($t = 4.56$, $p < 0.001$), indicating a large effect size (Cohen's $d = 1.18$).

Complementing the cognitive outcomes, the assessment of mathematical thinking disposition revealed equally pronounced differences between the experimental and control groups. Table 2 presents the mean scores for each dispositional aspect, demonstrating the experimental group's consistently more positive attitudes toward mathematics.

Table 2. Mean Scores of Mathematical Thinking Disposition by Aspect

Disposition Aspect	Experimental Group	Control Group	t-value	p-value
Curiosity	3.45	3.02	2.89	0.005
Perseverance	3.42	2.94	3.15	0.003
Open-mindedness	3.38	2.85	3.44	0.001
Self-confidence	3.44	2.96	3.22	0.002
Reflectivity	3.40	2.91	3.08	0.003
Overall	3.42	2.94	4.12	0.000

The dispositional data presented in Table 2 reveals that experimental group students demonstrated significantly more positive mathematical thinking dispositions across all measured aspects. The largest difference was observed in open-mindedness (0.53 points), followed by self-confidence (0.48 points), reflectivity (0.49 points), perseverance (0.48 points), and curiosity (0.43

points). The overall dispositional score showed a substantial difference of 0.48 points between groups ($t = 4.12$, $p < 0.001$), representing a large effect size (Cohen's $d = 1.06$).

Discussion

The findings of this study provide compelling evidence for the effectiveness of targeted pedagogical interventions in simultaneously enhancing elementary students' creative thinking abilities and mathematical thinking dispositions. The substantial differences observed between experimental and control groups across all measured indicators align with contemporary theoretical frameworks emphasizing the interconnected nature of cognitive and affective development in mathematical learning.

The experimental group's superior performance in creative thinking ability, particularly in the elaboration dimension, supports Guilford's (1986) multidimensional conceptualization of creativity. The 9.6-point difference in elaboration scores suggests that students in the experimental condition developed enhanced capacity to expand upon their initial ideas, providing detailed explanations and sophisticated reasoning processes. This finding corroborates research by Putri and Fitria (2020), who demonstrated that elementary students possess substantial creative potential when provided with appropriate learning environments that encourage idea exploration and detailed expression of thought processes. The significant improvements in originality and flexibility indicators further validate Sternberg's (1999) assertion that creativity enables unprecedented problem-solving capacity, as experimental group students demonstrated greater willingness to explore unconventional solution strategies and adapt their approaches based on problem demands.

The concurrent enhancement of mathematical thinking disposition represents an equally significant finding, as it addresses the affective dimension that Martin (2000) identified as crucial for mathematical identity formation. The experimental group's superior performance across all dispositional aspects—curiosity, perseverance, open-mindedness, self-confidence, and reflectivity—indicates that the intervention successfully created psychological conditions conducive to positive mathematical engagement. These results align with findings from Dewi and Nugraheni (2019), who documented strong correlations between positive mathematical dispositions and persistent problem-solving behaviors. The particularly notable improvement in self-confidence (0.48 points) is especially significant, as Cobb and Hodge (2011) emphasize that students' ability to perceive themselves as capable mathematics learners fundamentally influences their academic trajectory.

The relationship between enhanced creative thinking abilities and improved mathematical dispositions observed in this study supports theoretical frameworks proposed by contemporary researchers. Yuliani et al. (2022) documented positive correlations between these constructs, suggesting that students who engage in flexible, open-minded thinking also exhibit more active, reflective, and confident attitudes throughout mathematical learning processes. The present findings extend this understanding by demonstrating that targeted interventions can simultaneously develop both dimensions, creating a synergistic effect that amplifies overall mathematical learning outcomes.

From a neuropsychological perspective, the observed improvements align with contemporary understanding of creative thinking as emerging from dynamic interactions among ordinary cognitive processes (Abraham & Windmann, 2007; Ward & Finke, 1995). The experimental group's enhanced performance across multiple creativity indicators suggests improved coordination of memory-based processing, cognitive control, attention regulation, and reasoning capabilities—functions that Benedek and Fink (2019) and Gray et al. (2019) identify as fundamental to creative thinking. This coordination likely contributed to the simultaneous development of positive dispositions, as students experienced greater success and satisfaction in their mathematical activities.

The educational implications of these findings are substantial, particularly given the contemporary emphasis on developing 21st-century competencies in elementary education. The results suggest that instructional approaches emphasizing exploration, multiple solution strategies, and reflective practices can effectively address both cognitive skill development and affective

disposition formation. This aligns with recommendations from Trilling and Fadel (2009) and Hwang et al. (2007) regarding the critical importance of creativity development for mathematical problem-solving capabilities.

However, several limitations must be acknowledged when interpreting these results. The study's implementation within a single educational institution limits the generalizability of findings across diverse educational contexts. Additionally, the three-week intervention period, while sufficient to detect significant differences, may not fully capture the long-term sustainability of observed improvements. Future research should investigate whether these gains persist over extended periods and across varied mathematical content areas.

The measurement of mathematical thinking disposition through self-report questionnaires, while providing valuable insights into students' attitudes, may not fully capture the complexity of dispositional development. Subsequent studies would benefit from incorporating observational measures and longitudinal designs to provide more comprehensive understanding of how dispositions evolve throughout elementary education.

Despite these limitations, the study's findings contribute significantly to the growing evidence base supporting integrated approaches to cognitive and affective development in mathematics education. The demonstrated effectiveness of interventions targeting both creative thinking abilities and mathematical dispositions provides practical guidance for educators seeking to implement more holistic instructional practices. These results suggest that mathematics education reform initiatives should prioritize the development of learning environments that simultaneously challenge students intellectually while nurturing positive attitudes toward mathematical engagement.

CONCLUSION

This quasi-experimental study provides compelling evidence that targeted pedagogical interventions can simultaneously enhance elementary students' mathematical creative thinking abilities and mathematical thinking dispositions. The experimental group demonstrated significantly superior performance across all measured dimensions, with particularly notable improvements in elaboration skills (9.6-point difference) and open-mindedness disposition (0.53-point difference). The large effect sizes observed for both creative thinking ability (Cohen's $d = 1.18$) and mathematical thinking disposition (Cohen's $d = 1.06$) indicate that these differences represent practically meaningful educational outcomes rather than merely statistically significant variations.

The synergistic relationship between cognitive and affective development revealed in this investigation contributes substantially to mathematics education theory by demonstrating that creative thinking abilities and positive dispositions can be cultivated concurrently through appropriately designed instructional approaches. This finding challenges traditional pedagogical models that treat cognitive skill development and affective engagement as separate educational objectives. The research extends existing theoretical frameworks by providing empirical evidence that Guilford's creativity dimensions and Martin's dispositional constructs respond positively to integrated instructional interventions, supporting contemporary understanding of mathematics learning as a holistic developmental process.

The practical implications of these findings are significant for elementary mathematics education reform. The results suggest that educators should prioritize learning environments that encourage exploration, multiple solution strategies, and reflective practices rather than focusing exclusively on procedural skill acquisition. The demonstrated effectiveness of approaches that simultaneously target cognitive abilities and affective dispositions provides actionable guidance for curriculum developers and teacher preparation programs. Furthermore, the study's findings support policy initiatives emphasizing 21st-century skill development, as creative thinking abilities represent essential competencies for navigating increasingly complex global challenges.

Future research should examine the long-term sustainability of these improvements and investigate the transferability of findings across diverse educational contexts and mathematical

content areas. Additionally, longitudinal studies incorporating observational measures could provide deeper insights into the developmental trajectory of creative thinking abilities and mathematical dispositions throughout elementary education, ultimately informing more effective instructional practices that prepare students for lifelong mathematical engagement and success.

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May the results of this research contribute meaningfully to the development of mathematics education at the elementary school level and serve as inspiration for future research.

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