

The Effect of GEFT Based Cognitive Style on Students Mathematical Creative Thinking Ability

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Abstract. This study aims to analyze the effect of cognitive style on students' mathematical creative thinking skills. This study uses an ex post facto approach with a 2×2 factorial design (gender \times cognitive style) and was conducted on 10th grade students at Senior High School 5 Tegal City in the 2025/2026 academic year. The research sample consisted of 49 students selected through proportional stratified random sampling. Cognitive ability was measured using the Group Embedded Figures Test (GEFT) to categorize students into field-dependent (FD) and field-independent (FI) cognitive styles, while mathematical creative thinking ability was measured through a mathematical creative thinking ability test. Data analysis used two-way ANOVA to test main effects and interactions. The results showed a significant difference in mathematical creative thinking ability between FD and FI students, with higher achievement in the FI group. Meanwhile, differences based on gender and gender \times cognitive style interactions were not significant. These findings confirm that cognitive ability influences students' mathematical creative thinking ability, so learning needs to consider students' cognitive characteristics to optimize the development of mathematical creative thinking.

Keywords: Cognitive Ability, Group Embedded Figures Test, Environment Dependent, Environment Independent, Mathematical Creative Thinking.

1. Introduction

This study contributes to the achievement of the Sustainable Development Goals (SDGs) established by the United Nations, particularly SDG 4 (Quality Education). This study examines how GEFT-based cognitive styles influence students' mathematical creative thinking abilities. The findings of this study are expected to strengthen more adaptive and innovative teaching practices, as well as foster the

development of students' creativity and engagement in mathematics learning. Education is an important aspect that cannot be separated from modern society. Along with the advancement of civilization, technological developments are occurring rapidly and affecting almost all aspects of life, including education (Sezer & Namukasa, 2021; Wijayanti & Sugiharto, 2025).

In addition, increasingly dynamic global competition requires every individual to be able to adapt quickly to change. In this context, creative and innovative thinking skills are important assets for individuals to face challenges and solve various problems in the future (Fahmi & Jumadi, 2023; Prabaningtias et al., 2022; Sarikaya & Denis-Celiker, 2022). This is in line with Batcha's view (Batcha et al., 2019) that creative thinking is the ability to generate diverse new and meaningful ideas/strategies to find various alternatives to solve problems, especially in mathematics learning. This is in line with the view that emphasizes that the development of creative thinking is important because it helps students explore various possibilities, develop original ideas, and choose the most appropriate strategies for solving mathematical problems (Costa-Cordella et al., 2021; Mumcu et al., 2023; Weinhandl et al., 2020).

Senior high schools are educational institutions that play an important role in preparing competent human resources (Dani, 2018; Hill et al., 2005; Sumarmo, 2006). Creative thinking skills are an important aspect of education, especially in mathematics learning (Beroíza-Valenzuela & Salas-Guzmán, 2024). Quiroz (Quiroz et al., 2024) emphasizes that creative thinking needs to be developed because it is the basis for problem solving.

Creative thinking skills in mathematics encourage students to find various ways to solve problems. Creative thinking includes the ability to generate new ideas by combining, modifying, or expanding existing ideas (Bertrand & Namukasa, 2020; Sobral & Sobral, 2021; Suárez et al., 2024). Furthermore, creative thinking is the ability to be sensitive to situations and recognize problems that need to be solved (Pastor-Vicedo et al., 2021). Thus, creative thinking is not only about producing something new, but also about how individuals view problems from different perspectives and find innovative solutions (Wahyuni et al., 2024).

The results of a preliminary study conducted at Senior High School 5 Tegal City on the subject of Two-Variable Linear Equation Systems show that students still have difficulty meeting the indicators of creative thinking skills. This indicates the need for a learning approach that encourages students to think more openly. Students' creative thinking skills, which are part of their mathematical abilities, are influenced by various factors, one of which is cognitive ability.

Cognitive ability relates to how a person receives, processes, and responds to information, and cognitive ability is divided into two types, namely Field Independent (FI) and Field Dependent (FD). Although these two types have

relatively the same level of intelligence, the way they process information is different. Students with FI abilities tend to be more independent, analytical, and fond of mathematics and science, while students with FD abilities are more responsive to social and humanities fields.

Research by Wahyuni (Alvarenga & Braga, 2024; Sjunnesson, 2020; Wahyuni et al., 2024) shows that FI students excel in science, while FD students excel in the arts. This indicates that cognitive abilities can influence the level of creativity in thinking. In addition to cognitive abilities, psychological factors are also believed to influence students' creative thinking abilities. Biological differences and brain structure cause differences in the way people think, process information, and deal with problems (Tamrin et al., 2011). Several studies have produced different findings (Hendriana & Kadarisma, 2019). There are significant differences between the creative thinking abilities of men and women, with men excelling in logical reasoning, while women are stronger in precision and accuracy of thinking (Onoshakpokaiye, 2024).

Previous studies have also shown mixed results regarding the relationship between psychological conditions and mathematical ability (Turyanto et al., 2019; Wijayanti & Sugiharto, 2025), finding that male students have higher mathematical ability than female students. Based on these findings, this study aims to: (1) determine whether there are differences in creative thinking abilities between students with field-dependent and field-independent cognitive abilities, (2) determine whether there are differences in creative thinking abilities between male and female students, and (3) analyze whether there is an interaction between cognitive abilities and psychological conditions on students' mathematical creative thinking abilities.

2. Methodology

The research approach used was quantitative with an ex post facto type (Ambarwati & Kurniasih, 2021; Los, n.d.). The design applied was a 2×2 factorial (gender × cognitive style) to test the main effect and interaction on mathematical creative thinking abilities.

This study was conducted on 10th grade students at Senior High School 5 Tegal City in the 2025/2026 academic year. The sample analyzed consisted of 49 students selected through proportionate stratified random sampling (summary: FD=32, FI=17; female=26, male=23).

Cognitive ability was measured using the Group Embedded Figures Test (GEFT) to group students into field dependent (FD) and field independent (FI) cognitive styles. Mathematical creative thinking ability was measured through an essay test consisting of 4 items on 2×2 order matrix material with indicators of fluency, flexibility, originality, and elaboration.

Figure 1 shows a simple target shape inserted (hidden) within a more complex image pattern. In this task, test participants were asked to find the target shape

among the overlapping lines and patterns, then mark or trace the target shape accurately according to the available example.

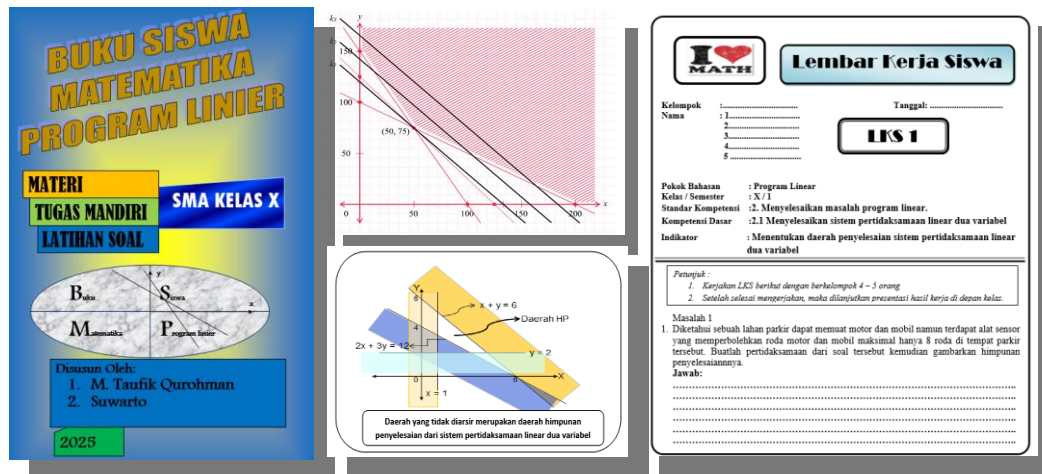


Figure 1. An example of an embedded image stimulus depicting a simple target image embedded in a complex pattern to be identified by test participants.

In the context of mathematics learning, the skill of separating important information from a complex background is also relevant when students learn Two Variable Linear Equation Systems (SPLDV) material. For example, when solving SPLDV, students need to identify key information from the story problem, distinguish between variables and coefficients, choose a solution method (elimination, substitution, or graphing), and interpret the intersection point or solution pairs that satisfy both equations (Darkasyi et al., 2014; Kurniawan et al., 2017; Nasution & Ahmad, 2018). Thus, abilities such as those in embedded-figures stimuli can support students' accuracy and focus in processing information when solving SPLDV problems.

Figure 2 shows a descriptive comparison of students' mathematical creative thinking scores based on gender and cognitive style. The bar graph shows that female students have a higher average score than male students (Female: 74.35; Male: 66.22). However, the error bars (standard deviation) in both groups appear to be quite large, indicating a wide variation in ability within each group, so that the difference in means between groups needs to be interpreted with caution.

In addition, Figure 2 shows a clearer pattern in the comparison of cognitive styles, namely that students with a field independent (FI) cognitive style had higher average scores than field dependent (FD) students (FI: 78.41; FD: 66.69).

The FI group also showed a smaller standard deviation than the FD group, so that the performance of FI students tended to be more consistent. In general, this graph

supports the conclusion that cognitive style is more closely related to mathematical creative thinking achievement than gender in this research sample.

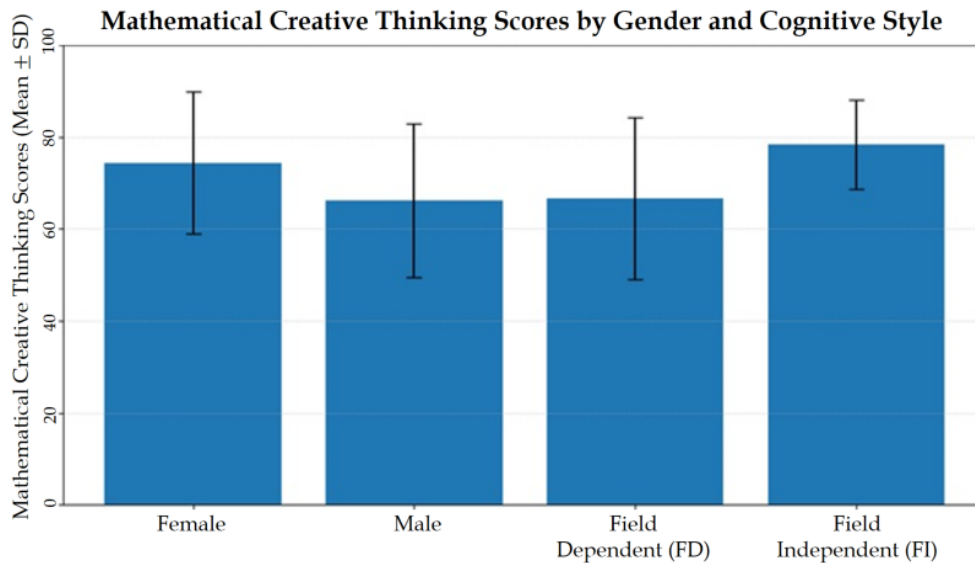


Figure 2. Comparison of students' mathematical creative thinking scores based on gender and cognitive style.

Data analysis used a two-way ANOVA. Before the ANOVA test, the data were tested for normality and homogeneity (see the Table 1).

Table 1: 2×2 Factorial Design (Gender × Cognitive Style)

Variable	Cognitive Style (B1) Field Dependent	Cognitive Style (B2) Field Independent
Gender (A1) Female	A1B1	A1B2
Gender (A2) Male	A2B1	A2B2

3. Results

3.1. Student Cognitive Style (GEFT)

A summary of cognitive styles based on GEFT results is presented in Table 2.

Table 2: Student Cognitive Style Data

Grade	Gender	Cognitive Style	Number of Students
X.1	Female	Field Dependent (FD)	16
X.3	Female	Independent Field (FI)	10
X.1	Male	Field Dependent (FD)	16
X.3	Male	Independent Field (FI)	7

Based on Table 2, the distribution of cognitive styles of students identified through GEFT shows that the number of students with cognitive style *field dependent* (FD) more than *field independent* (FI). Of the total 49 students, there were 32 students

categorized as FD (16 female students and 16 male students), while students categorized as FI amounted to 17 students (10 female students and 7 male students).

This finding indicates that the majority of students tend to be more influenced by context when processing information (FD), while some others have a tendency to be more analytical and independent in separating important information from the background (FI), which in turn has the potential to affect students' strategies and results in completing mathematics tasks. Based on Table 2, there are more students with FD cognitive style ($n=32$) than FI ($n=17$).

3.2. Description of Mathematical Creative Thinking Scores

Table 3: Description of Creative Thinking Scores Based on Gender

Gender	N	Average	Elementary	Min	Max
Female	26	74.35	15.46	41	100
Male	23	66.22	16.79	26	93

Based on Table 3, descriptively the mathematical creative thinking ability of female students appears higher than male students. The average score of female students was 74.35 ($SD = 15.46$) with a score range of 41-100, while the average score of male students was 66.22 ($SD = 16.79$) with a score range of 26-93. However, the standard deviation in both groups showed considerable variation in scores, especially in the male group, so the average difference needs to be interpreted carefully because it still allows for overlapping abilities between individuals in both groups.

Table 4: Description of Creative Thinking Scores Based on Cognitive Style

Cognitive Style	N	Average	SD	Min	Max
Field Dependent (FD)	32	66.69	17.58	26	100
Field Independent (FI)	17	78.41	9.75	59	93

Based on Table 4, descriptively there are differences in mathematical creative thinking ability in terms of cognitive style, where students with cognitive style *field independent* (FI) obtained a higher average score (78.41; $SD = 9.75$) than students *field dependent* (FD) (66.69; $SD = 17.58$). The range of scores of the FI group was 59-93, while the FD group was wider, namely 26-100, which indicates a greater variation in ability in the FD group. This finding indicates a tendency that FI students have better and more consistent mathematical creative thinking achievements, possibly due to the FI character who is more analytical and able to focus attention on important information when solving problems, while FD students tend to be more influenced by context so that their performance is more varied. Descriptively, the average score of female students is higher than that of male students, but the difference is not significant in inferential testing. The average score of FI students is higher than that of FD students, indicating a tendency for better creative thinking achievement in the FI group.

3.3. Prerequisite Tests (Normality and Homogeneity)

Table 5: Results of Normality Test (Chi-square)

Group	N	Calculated Chi-square	Chi-square table	Conclusion
A1B1	16	4.89	5.99	Normal (H_0 accepted)
A1B2	7	2.05	3.84	Normal (H_0 accepted)
A2B1	16	5.85	5.99	Normal (H_0 accepted)
A2B2	10	1.62	5.99	Normal (H_0 accepted)

Based on Table 5, the results of the normality test using Chi-square show that all data groups fulfill the assumption of normality. This can be seen from the calculated Chi-square value in each group (A1B1 = 4.89; A1B2 = 2.05; A2B1 = 5.85; A2B2 = 1.62) which are all smaller than the Chi-square table at the significance level used, so that H_0 is accepted in each group. Thus, the data score of mathematical creative thinking ability in all combinations of groups (based on gender and cognitive style) can be declared normally distributed and meet one of the prerequisites to continue the analysis using two-way ANOVA.

Table 6: Results of the Variance Homogeneity Test (Chi-square)

Number of Groups	Chi-square calculated	Chi-square table	Conclusion
4	4.82	7.81	Homogeneous variance (H_0 accepted)

Based on Table 6, the results of the variance homogeneity test using Chi-square show that the variance between groups is homogeneous. This is indicated by the calculated Chi-square value of 4.82 which is smaller than the Chi-square table of 7.81, so H_0 is accepted. With the fulfillment of the assumption of homogeneity of variance in the four groups analyzed, the data is suitable to proceed to the inferential analysis stage using two-way ANOVA because one of the main prerequisites has been met. The results of the prerequisite test show that the data are normally distributed and the variance is homogeneous, so that two-way ANOVA can be applied.

3.4. Two-Way ANOVA Results

Table 7: Summary of Two-Way Analysis of Variance Results ($\alpha = 0.05$)

Source of Variation	Calculated F	F table	Decision
Gender (A)	3.96	4.06	H_0 accepted (not significant)
Cognitive style (B)	6.77	4.06	H_0 rejected (significant)
Interaction (A×B)	0.28	4.06	H_0 accepted (not significant)

Based on Table 7, the results of two-way ANOVA at the significance level of 0.05 shows that cognitive style factors provide a significant main effect on students'

mathematical creative thinking ability, because the value of F count for cognitive style (6.77) is greater than F table (4.06), so H0 is rejected. In contrast, the gender factor has no significant effect because F count (3.96) is smaller than F table (4.06), so H0 is accepted. In addition, the interaction between gender and cognitive style is also not significant (F count = 0.28 < 4.06), which means the effect of cognitive style on mathematical creative thinking ability tends to be consistent in both male and female students, without any combination of influences that strengthen or weaken each other. The ANOVA results show that cognitive style has a significant main effect, while gender and interaction are not significant.

3.5. Discussion

The results of this study indicate that cognitive style based on GEFT influences students' mathematical creative thinking abilities. Students with a *field independent* (FI) cognitive style achieved higher scores than students with a *field dependent* (FD) style (Buxton, 2005; Qurohman, 2025; Rofifah & Meiliasari, 2025). Conversely, gender and the interaction between gender and cognitive style did not show a significant effect. These findings confirm that differences in mathematical creative thinking achievement are more related to students' cognitive characteristics than to gender differences.

The strengths of the FI group can be explained by their tendency to be more analytical, independent, and able to separate important information from distracting context. In solving math problems that require *fluency*, *flexibility*, *originality*, and *elaboration*, FI students generally find it easier to understand the structure of the problem, choose the appropriate representation, and systematically develop alternative strategies. The ability to focus attention on relevant information supports the emergence of variations in solution methods (flexibility) and more detailed step-by-step explanations (elaboration), resulting in higher mathematical creative thinking scores for the FI group compared to the FD group.

Meanwhile, the absence of significant differences based on gender indicates that mathematical creative thinking ability in the context of this study is not determined by gender (Dani, 2018; Onoshakpokaiye, 2024; Zulkipli & Musa, 2022). This may be because relatively equal learning opportunities, classroom experiences, and treatment allow both male and female students to perform comparably. Although descriptively the average scores of female students appear to be higher, the variation in scores within each group is quite large so that the average difference is not strong enough to be considered statistically significant.

No interaction effect between gender and cognitive style was found, indicating that the superiority of FI over FD appears consistently in both male and female students. Thus, efforts to develop mathematical creative thinking should emphasize learning adjustments based on cognitive characteristics (Clements & Sarama, 2007; Fahmi & Jumadi, 2023; Jin et al., 2022; Noviyanto & Wardani, 2020; Sairo et al., 2021; Yazlık & Çetin, 2023). FD students can be supported through more structured scaffolding,

step-by-step examples, guiding questions, and visual aids to make it easier for them to grasp key information. Conversely, FI students can be given more challenging and open-ended tasks, space to explore strategies, and problem-solving activities that encourage originality and enrichment of ideas.

Although the findings of this study are quite clear, the results still need to be understood by considering the limitations of the study, such as the relatively small sample size and location coverage of only one school, an *ex post facto* design that does not allow full control of external variables, and a limited number of creative thinking instruments. Further research should involve a broader sample, use an experimental design to test the effectiveness of learning tailored to cognitive styles, and add qualitative studies (e.g., analysis of thinking processes or solution steps) to gain a deeper understanding of the differences between FD and FI in terms of mathematical creative thinking indicators.

4. Conclusion

In conclusion, this study shows that cognitive styles based on GEFT have a significant influence on students' mathematical creative thinking abilities, where students with a field independent (FI) cognitive style have higher achievements than field dependent (FD) students. Conversely, no significant differences were found based on gender or the interaction between gender and cognitive style on mathematical creative thinking abilities, so the development of mathematics learning needs to further consider students' cognitive characteristics to optimize creative thinking abilities.

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