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A STUDY OF DIFFERENCES IN MATHEMATICAL REASONING AMONG JUNIOR HIGH STUDENTS WITH FIELD INDEPENDENT AND FIELD DEPENDENT COGNITIVE STYLES

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ABSTRACT
Mathematical reasoning plays a vital role in helping students understand concepts, identify patterns, and solve problems effectively. This study aimed to investigate whether students with Field-independent (FI) and Field-dependent (FD) cognitive styles exhibit significant differences in their mathematical reasoning abilities. To examine the variation in students' reasoning skills according to their cognitive styles, a quantitative approach using a comparative method was employed. After a preliminary test of homogeneity of variances using Levene's Test, which produced a significance value of 0.820 (> 0.05), Data were analyzed using an Independent Samples t-test. The results indicated that the assumption of equal variances was met, thereby validating the use of parametric analysis. The t-test revealed a statistically significant difference between the two cognitive style groups, with a t-value of 3.232, 40 degrees of freedom, and a significance level of 0.002 (< 0.05). In terms of mathematical reasoning, students identified as FI performed better than those classified as FD. This finding suggests that while FD learners tend to rely more on external cues and structured guidance when solving problems, FI learners are generally more analytical and able to process information independently. The findings also suggest that pupils' capacity for mathematical reasoning is significantly influenced by their cognitive style. These results emphasise the necessity of varied teaching strategies that take into account both learning styles from a pedagogical standpoint. Teachers can build more inclusive, balanced, and productive mathematics learning environments by incorporating exploratory, Problem-based tasks are more suitable for FI learners, whereas structured instructional approaches better support FD learners.
Keywords: Mathematical Reasoning Ability, Cognitive Style, Field Independent, Field Dependent.

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PRELIMINARY

Education is a deliberate, planned, and structured process aimed at fully developing the potential and talents of each learner (Ulfa, 2021). Through education, children not only acquire general knowledge but are also trained to think logically, solve problems, and reason skills that are particularly important in areas requiring systematic thinking, such as mathematics.(Polman et al. 2021) Children possess a natural capacity to understand numerical concepts; however, this understanding is optimized when learning is provided in meaningful and contextually relevant situations (Parameswari & Kurniyati 2020). Providing enjoyable and contextualized mathematics learning experiences, both at home and at school, is essential to support the development of their abilities and to prevent a loss of confidence in their mathematical competence upon entering formal schooling (Fong et al. 2025).

In this regard, mathematics plays a strategic role in fostering students' logical, analytical, and critical thinking abilities, as well as in developing their mathematical reasoning skills (Sikky Rokhayah & Khamdun 2021). Mathematical reasoning refers to the logical thought process employed to draw conclusions or construct arguments based on verified facts and established concepts. Hence, reasoning can be defined as a systematic cognitive process that produces valid statements derived from premises assumed to be true (Yusril & Rachmani, 2025).

Mathematical reasoning serves as a fundamental component in understanding and mastering various mathematical concepts (Teoh et al. 2025). This ability not only reflects cognitive intelligence but also demonstrates how students interpret, connect, and communicate mathematical ideas meaningfully In simple terms, mathematical reasoning can generally be divided into two main types: inductive reasoning and deductive reasoning**.** Inductive reasoning involves examining specific cases to infer general principles or patterns, whereas deductive reasoning starts from established general rules or theories and applies them to derive specific, logical conclusions. (Yusdiana & Hidayat 2018). Within the learning process, mathematical reasoning becomes evident when students are able to link previously acquired concepts to generate appropriate solutions for mathematical problems (Oktaviana et al. 2021). In terms of skill development, tasks that require high levels of logical reasoning demand a deep engagement of students' cognitive processes (Bao, & Gao, 2025). The integration of formal mathematical reasoning ensures that students not only comprehend abstract concepts but also understand their applications in real-world contexts (Canonigo 2025).

Nevertheless, empirical evidence indicates that Indonesian students' mathematical reasoning ability remains considerably low. The Programme (OECD 2023b) reported that Indonesian students scored 379 in mathematical reasoning and problem-solving, significantly below the OECD average of (OECD 2023a). This result suggests that many students face difficulties when dealing with tasks that require analytical and logical reasoning. In addition, the 2019 TIMSS revealed that Indonesian eighth-grade students obtained an average score of 397, which is considerably below the international average of 500. These findings emphasize the urgent need to strengthen students' mathematical reasoning skills through the enhancement of classroom practices and instructional strategies.

The low level of students' mathematical reasoning ability may be influenced by various factors, such as cognitive style, learning environment, parental support, and individual learning characteristics. Cognitive style refers to an individual's consistent pattern of perceiving, processing, and organizing information (Mubarok, 2018; Cissé et al. 2025; Sternberg 1997), which shapes how learners respond to academic tasks.

(Pithers, 2006) categorizes cognitive style into two types: field-dependent and field-independent, each of which demonstrates distinct characteristics in visual cognition and information processing (Zhu et al. 2024). These differences lead students to vary in how they interpret, structure, and utilize information during the learning process. Moreover, cognitive style is associated with related constructs such as decision-making patterns, problem-solving strategies, and learning preferences (Yan 2010). Collectively, these aspects influence how students learn and reason, thereby contributing to their mathematical reasoning ability.

According to (Giancola & D'Amico 2022) and (Jiang et al. 2025), Students with a Field-independent (FI) cognitive style generally demonstrate stronger abilities in understanding abstract ideas than their peers with a Field-dependent (FD) cognitive style. (Davey 1990). further emphasized that individuals who analyze information without considering contextual or environmental factors may encounter difficulties in performing accurate evaluations and achieving balanced judgments. Several studies have highlighted that Cognitiv style as a major influence on the way students reason, approach, and solve problems (Guisande et al. 2007)

Cognitive style is commonly classified into two major dimensions: Field-independent (FI) & Field-dependent (FD). Another group of learners with this style contained those who were analytical, logical and independent while processing information. In contrast, When understanding and making sense of information, students with a Field Dependent (FD) cognitive style frequently rely more on external cues and surrounding settings. (Zivi et al. 2025). Previous research findings, such as those reported by (Giancola et al. 2022), indicate that FI students possess superior abilities in comprehending abstract concepts compared to FD students. However, most of these studies have primarily focused on conceptual understanding, with limited exploration of how cognitive style influences students' mathematical reasoning ability, particularly in mathematical topics that demand logical and conceptual thinking, such as exponential numbers.

In learning exponents, students must reason about conceptual relationships, recognize the patterns underlying exponent properties, and draw valid conclusions. These reasoning demands may differ based on cognitive style: field-independent (FI) students are typically better at deconstructing the structure of exponent concepts and reasoning through abstract patterns independently, whereas field-dependent (FD) students often require more concrete contexts to understand conceptual connections and may struggle to reason through generalizations. Therefore, this study examines whether there is a difference in mathematical reasoning ability between FI and FD students in the topic of exponential numbers.To address this objective, the following hypotheses were proposed:

H_0: Students with field-independent and field-dependent cognitive styles do not differ significantly in their mathematical reasoning ability

H_1: Students with field-independent and field-dependent cognitive styles do differ significantly in their mathematical reasoning ability

METHODS

In order to determine if students with FI and FD cognitive styles differ in their capacity for mathematical thinking, this study used a quantitative research method with a comparative approach. Because it concentrates on gathering and analysing numerical data, which are subsequently processed using inferential statistical tests to assess the developed hypotheses, the quantitative approach was selected.

(Mackiewicz 2018). A comparative method was applied to compare two or more groups with distinct characteristics to determine the influence or differences in a specific variable (Sugiyono 2022). In this context, quantitative data analysis enables the researcher to objectively identify variations in students' mathematical reasoning ability based on their cognitive styles (Ary et al. 2018)

Moreover, this approach provides a strong foundation for generalizing the research findings within the context of mathematics education (Fraenkel & Hyun, 2011) All 120 eighth-graders at a certain junior high school made up the study's population. Purposive sampling was used to choose 42 pupils as the research sample from this cohort. The sampling procedure was predicated on the idea that, in line with the goals of the study, individuals should represent both the Field Independent and Field Dependent cognitive style groups.

The Group Embedded Figures Test (GEFT) and a test of mathematical reasoning skills made up the data collection tools employed in this study. Based on their test results, pupils were classified using the GEFT into two cognitive style groups: Field Independent (FI) and Field Dependent (FD). The GEFT tool created by was used in this classification(Witkin et al. 1977), which has been widely recognized and validated in previous studies as a reliable tool for determining an individual’s cognitive style tendency (Schukajlow, Rakoczy, and Pekrun 2023)

Participants in the GEFT must find basic geometric shapes concealed behind increasingly intricate figures through a series of visual exercises. Field Independent people are individuals who can rapidly and accurately recognise these shapes, while Field Dependent people have difficulty finding them. Students were methodically categorised based on their cognitive styles using the GEFT, which served as the foundation for evaluating how well they could utilise mathematical reasoning to solve tasks that matched their individual cognitive traits.

Table 1. Criteria for Grouping Students by Cognitive Style

Score (S)	Cognitive Style
$0 \leq S \leq 9$	*Field Dependent*
$9 < S \leq 18$	*Field Independent*

In the meantime, students' ability to comprehend concepts, create generalisations, and come to logical conclusions when solving mathematical problems was evaluated using the mathematical reasoning aptitude test. The results were displayed using predefined categories after the data were categorised based on the markers of mathematical reasoning ability. The following formula was used to process the exam results using percentage calculations in order to determine the students' level of mathematical reasoning proficiency.

$$P = \frac{f}{n} . 100\ \%$$

Note:

P: Percentage

f: Frequency of students’ responses

n: Total score (maximum score)

This section presents the quantitative findings examining how students’ mathematical reasoning abilities vary according to their cognitive styles, namely Field Independent (FI) and Field Dependent (FD). The presentation of results is organised into several key components. First, the outcomes of the Group Embedded Figures Test (GEFT) are outlined to classify students into the FI and FD categories. This is followed by an analysis of the mathematical reasoning test to illustrate students’ performance in solving problems relative to their respective cognitive styles. The subsequent part reports the results of the homogeneity and normality assessments, which verify that the dataset meets the assumptions required for parametric analysis. Finally, the Independent Samples t-test is employed to determine whether the two cognitive-style groups differ significantly in their mathematical reasoning ability.

RESULT AND DISCUSSION

This section presents the quantitative findings examining how students' mathematical reasoning abilities vary according to their cognitive styles, namely Field Independent (FI) and Field Dependent (FD). The presentation of results is organised into several key components. First, the outcomes of the *Group Embedded Figures Test (GEFT)* are outlined to classify students into the FI and FD categories. This is followed by an analysis of the mathematical reasoning test to illustrate students' performance in solving problems relative to their respective cognitive styles. The subsequent part reports the results of the homogeneity and normality assessments, which verify that the dataset meets the assumptions required for parametric analysis. Finally, the Independent Samples t-test is employed to determine whether the two cognitive-style groups differ significantly in their mathematical reasoning ability.

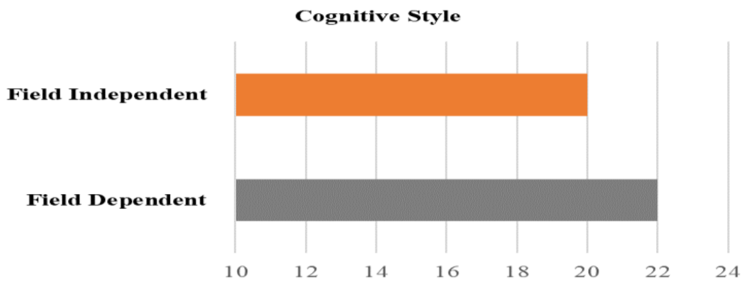

Figure 1. Cognitive Style Category

The grouping of students according to their cognitive styles as determined by the *Group Embedded Figures Test (GEFT)* is shown in Figure 1. The students were divided into two groups based on their cognitive style: Field-Independent (FI) and Field-Dependent (FD). The FI group consisted of 20 students, while the FD group consisted of 22 students. With a modest tendency for FD students to be more prevalent in the sample, these results point to a well equal distribution between the two cognitive style categories. This difference in cognitive approach provides a basis for additional research to examine how each group exhibits varying degrees of mathematical reasoning proficiency.

Table 2. Descriptives

		Kelas		Statistic	Std. Error
Penalran Matematis	FIeld Independent	Mean		71.8500	3.09437
		95% Confidence Interval for Mean	Lower Bound	65.3734	
			Upper Bound	78.3266	
		5% Trimmed Mean		72.6111	
		Median		71.0000	
		Variance		191.503	
		Std. Deviation		13.83845	
		Minimum		40.00	
		Maximum		90.00	
		Range		50.00	
	Field Dependent	Mean		58.3636	2.81427
		95% Confidence Interval for Mean	Lower Bound	52.5110	
			Upper Bound	64.2162	
		5% Trimmed Mean		58.9646	
		Median		58.5000	
		Variance		174.242	
		Std. Deviation		13.20009	
		Minimum		30.00	
		Maximum		75.00	
		Range		45.00	

To evaluate students' mathematical reasoning in relation to their cognitive styles, a descriptive analysis was conducted prior to the normality assessment. The results indicate that learners classified as FI obtained scores ranging from 40 to 90, with a mean of 71.85 and a standard deviation of 13.84. The distribution of FI scores appeared relatively stable, reflected by a median of 71.00 and a 5% trimmed mean of 72.61.

Meanwhile, students identified as FD achieved scores between 30 and 75, yielding a mean of 58.36 and a standard deviation of 13.20. The median score of 58.50 and a 5% trimmed mean of 58.96 suggest a consistent pattern of performance within the FD group.Taken together, these descriptive findings show that FI students demonstrated higher levels of mathematical reasoning compared to their FD counterparts. These results served as the basis for the subsequent step, which involved testing for normality before proceeding to inferential statistical analyses.

Table 3. Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Reasoning Ability	Field Independent	.147	20	.200[*]	.945	20	.294
	Field Dependent	.220	22	.007	.919	22	.072

To make sure that the mathematical reasoning scores of students in both groups FI and FD were regularly distributed, a normality test was performed. The Shapiro-Wilk approach, which is advised for small sample sizes, was used in this test. According to the analysis results, the significant value was 0.072 for the FD group and 0.294 for the FI group. It may be inferred that the data from both groups are normally distributed because both values are higher than the significance level of α = 0.05. This shows that the data are appropriate for additional analysis using parametric tests and that the assumption of normality is satisfied.

Figure 2. Boxplot of Mathematical Reasoning Ability Based on Cognitive Style

Figure 2 presents a boxplot comparing the mathematical reasoning performance of students with FI and FD cognitive styles. As illustrated in the figure, the median score of the FI group is higher than that of the FD group. The FD students show a score range from 30 to 75, while the FI group demonstrates a broader spread of scores, with values extending from approximately 40 up to 90.

Students' reasoning skills within this cognitive style tend to be more diverse, as evidenced by the more varied data distribution for the FD group. The FD group, on the other hand, exhibits a narrower range, indicating that the mathematical reasoning skills of the pupils in this group are comparatively more uniform. In comparison to students with a FD cognitive style, the visualisation generally shows that students with a FI cognitive style typically exhibit higher levels of mathematical reasoning ability.

Table 4. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.052	1	40	.820

Table 4 reports the results of Levene's Test, which examined whether the mathematical reasoning scores of FI and FD students had equal variances. The test produced a Levene Statistic of 0.052 with a significance value of 0.820. Since this value is above the 0.05 threshold, the variances of the two groups are considered equal, indicating that the homogeneity assumption is met. Therefore, the Independent Samples t-test can be applied under the equal-variances condition, ensuring that the parametric analysis remains valid and appropriate.

Table 5. Descriptive Analysis of Mathematical Reasoning Ability

	Kelas	N	Mean	Std. Deviation	Std. Error Mean
Penalran Matematis	FIeld Independent	20	71.8500	13.83845	3.09437
	Field Dependent	22	58.3636	13.20009	2.81427

Table 5 presents the descriptive statistics of students' mathematical reasoning scores according to their FI and FD cognitive styles. The FI group achieved a mean score of 71.85 with a standard deviation of 13.84, while the FD group recorded a mean of 58.36 and a standard deviation of 13.20. These results indicate that FI students generally demonstrate stronger mathematical reasoning skills than their FD peers.

The similar standard deviations suggest comparable levels of score variability in both groups. Overall, these descriptive findings provide an initial indication of potential differences between the two cognitive styles before conducting an inferential analysis using the Independent Samples t-test.

Table 6. Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Equal variances assumed	.052	.820	3.232	40	.002	13.48636	4.17311	5.05220	21.92053

Table 6 summarises the results of the Independent Samples t-test conducted to determine whether students' mathematical reasoning abilities differ significantly based on their cognitive styles, FI and FD. Prior to the t-test, Levene's Test confirmed that the homogeneity of variances assumption was met, as indicated by a significance value of 0.820, which is above the 0.05 threshold. Accordingly, the analysis proceeded using the "Equal variances assumed" row.

The t-test produced a two-tailed significance value of 0.002, a t-value of 3.232, and 40 degrees of freedom, all indicating a statistically significant difference between the two cognitive-style groups. The mean difference was 13.49 with a standard error of 4.17, and the 95% confidence interval (5.05 to 21.92) did not include zero. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted, confirming that students with FI and FD styles differ significantly in mathematical reasoning performance.

The findings show that FI students generally outperform FD students in mathematical reasoning tasks. This is consistent with a body of research that emphasizes not only the performance gap but also the underlying cognitive mechanisms. (Mutafaqih & Syahri, 2023) highlight that FI learners excel because they can filter out irrelevant information and focus on the structural features of a problem an ability that directly supports deductive reasoning and pattern recognition. In contrast, (Mirlanda et al. 2018)note that FD learners' reliance on external cues limits the extent to which they can engage in independent, multi-step reasoning. Although these studies differ in methodological approach, they converge on the idea that FI learners possess a stronger capacity for cognitive autonomy, which is central to mathematical reasoning.

Complementary evidence from (Mu et al. 2025) and (Prabowo, 2024) shows that environmental distractions intensify these differences. Additional stimuli increase cognitive load for FD learners more severely than for FI learners, and they reduce attentional stability across both groups. While these studies focus on digital contexts, their implications extend more broadly: they reveal that FD learners' vulnerability to distraction may further constrain their ability to sustain the cognitive effort required for reasoning tasks.

Collectively, the literature suggests a coherent pattern: FI learners' strengths in selective attention and structural analysis align closely with the demands of mathematical reasoning, whereas FD learners' contextual dependence and sensitivity to cognitive load create barriers to performing such tasks independently. Pedagogically, this reinforces the need for differentiated instruction providing structured scaffolds and visual anchors for FD learners while maintaining opportunities for inquiry and self-directed problem solving for FI learners to support reasoning across diverse cognitive styles.

CONCLUSION

The results of the Independent Samples t-test indicate a significant difference in mathematical reasoning abilities between students with FI and FD cognitive styles. With a two-tailed significance value of 0.002, a t-value of 3.232, and a mean difference of 13.49 (95% CI: 5.05–21.92), the analysis confirms that FI students outperform FD students in mathematical reasoning. Consequently, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted, demonstrating that cognitive style is a significant factor in students' mathematical reasoning performance.

Students with FI and FD cognitive styles show significant differences in mathematical thinking. FI students tend to excel because they can isolate relevant information from distracting contexts, attend to structural details, and reason independently. This ability allows them to recognize abstract patterns, draw logical conclusions, and solve problems systematically with minimal guidance. In contrast, FD students rely more on contextual cues and external support, as they process information more holistically and often depend on social interaction or teacher direction. Their collaborative learning tendencies make structured guidance, visual aids, and explicit scaffolding essential for understanding concepts and performing multi-step reasoning. These underlying mechanisms highlight how cognitive style shapes the way students process information and construct mathematical understanding.

From an educational perspective, these findings highlight the need to align mathematics instruction with students' cognitive styles. FI students excel in independent analytical reasoning, so discovery- and inquiry-based tasks can effectively stimulate their abilities, whereas FD students rely on guidance and contextual cues, making structured support, visual aids, and collaborative activities essential for their step-by-step reasoning. Aligning instructional strategies with these cognitive characteristics fosters an inclusive and effective learning environment and promotes the optimal development of mathematical reasoning for all students.

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