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Mapping Students' Creative Thinking in Geometry: A Cognitive Style-Based Needs Analysis

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ABSTRACT

Creative thinking is a key objective in geometry learning, yet prior studies have focused more on instructional interventions than on students' initial profiles. This study aims to map students' creative thinking in geometry and examine its variation across cognitive styles. A descriptive survey with comparative analysis was conducted involving 62 undergraduate students at UIN Siber Syekh Nurjati Cirebon. Creative thinking was measured using the Creative Thinking in Geometry Test (CTGT), covering fluency, flexibility, originality, and elaboration, while cognitive styles were classified into Field Independent (FI) and Field Dependent (FD). Data were analyzed using descriptive statistics and independent samples t-tests. The results indicate uneven performance across the dimensions, with fluency the highest and originality the lowest. Most students demonstrated moderate levels of creative thinking. FI students performed significantly better in fluency, flexibility, and originality than FD students, while no significant difference was found in elaboration. These findings suggest that cognitive style influences students' engagement with geometry tasks and highlight the importance of identifying students' initial profiles to inform instructional design.

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1. INTRODUCTION

Creative thinking has increasingly been positioned as a central objective in mathematics education, particularly in domains that demand spatial reasoning and conceptual abstraction. Geometry, as a field that integrates visualization, representation, and deductive reasoning, requires students not only to apply procedures but to generate flexible and original solutions. Recent scholarship underscores that creative thinking contributes positively to academic performance and mathematical problem-solving [1]. In geometry contexts, creativity supports students in navigating abstract relationships, multiple representations, and non-routine problem structures. However, prior studies have predominantly focused on post-intervention outcomes, with limited attention to students' baseline creative thinking profiles prior to instruction.

Innovative pedagogical approaches have demonstrated measurable gains in students' creative thinking. The integration of augmented reality (AR), for instance, has been shown to significantly enhance all indicators of mathematical creative thinking—fluency, flexibility, originality, and elaboration [2]. AR-based environments strengthen visualization and conceptual understanding in geometry learning [3], enabling interaction with three-dimensional representations from multiple perspectives [2]. Empirical evidence further indicates that students exposed to AR-supported instruction achieve higher post-test scores than those in conventional approaches [4]. Despite these advances, such studies rarely examine students' initial cognitive conditions as a basis for interpreting these improvements. However, the effects of such instructional approaches are not uniform across all cognitive domains [5], suggesting that students respond differently to the same learning environment. These findings indicate that while instructional innovation is effective, it does not fully explain how and why students differ in their creative thinking outcomes.

Similarly, problem-centered pedagogies such as Problem-Based Learning (PBL) have been found to promote higher-order cognitive skills, including creativity and problem-solving [5], [6]. However, the effects of such instructional approaches are not uniform across all cognitive domains [5], suggesting that students respond differently to the same learning environment. Open-ended problem scenarios foster divergent thinking [7], while collaborative learning settings enhance creative engagement [8]. In STEM–design thinking contexts, achievement improvements are closely tied to instructional design and learning environment rather than fixed learner characteristics [9]. This variation indicates a need better to understand learner differences prior to instructional implementation.

Within geometry learning specifically, technology-enhanced instruction aligned with Van Hiele phases has demonstrated stronger gains at intermediate abstraction levels [10]. Dynamic visualization tools improve students' conceptual understanding [11], and alignment between pedagogy and reasoning levels is crucial for sustained geometric development [12], [13]. Conceptual and procedural knowledge operate interdependently in shaping mathematical reasoning performance [14]. Nevertheless, how these capacities are initially distributed among learners remains insufficiently explored. This gap highlights the need for a diagnostic perspective that examines students' baseline creative thinking before instructional design decisions are made.

Collectively, post-2015 research converges on a shared insight: creative thinking in geometry can be enhanced through carefully designed instructional environments. However, this body of work largely concentrates on post-intervention gains. Despite robust evidence on the effectiveness of innovative instructional models, limited attention has been directed toward mapping students' baseline creative thinking profiles prior to pedagogical intervention. Studies frequently report improvement following AR integration [2] or PBL implementation [5], but the initial cognitive configurations that shape these improvements remain underexplored, with a clear understanding of students' starting profiles lacking. This is particularly concerning given that instructional innovation risks operating without diagnostic grounding. This study addresses this gap by positioning baseline creative thinking as a primary analytical focus rather than a secondary consideration.

Furthermore, although prior research acknowledges that cognitive effects vary across domains and abstraction levels [5], [10], differences in students' cognitive styles have rarely been examined as a basis for instructional needs analysis. If conceptual and procedural reasoning are interdependent [14], and if creativity mediates problem-solving performance [5], then variations in cognitive processing tendencies may shape how students engage with geometry tasks. Thus, the problem extends beyond instructional effectiveness toward understanding how learner characteristics interact with task demands.

In other words, before designing or refining instructional models, it is necessary to diagnose how creative thinking is currently distributed across learners and whether cognitive style differences signal differentiated instructional requirements. This study is guided by two research questions: (1) What are students' baseline creative thinking profiles in geometry? Moreover, (2) How do these profiles differ across cognitive styles?

Responding to this gap, the present study maps students' creative thinking profiles in geometry and examines how these profiles differ across cognitive styles. Rather than evaluating intervention outcomes, this research adopts a survey-based needs analysis approach within a university context.

By identifying baseline patterns across fluency, flexibility, originality, and elaboration, the study seeks to provide a structured diagnostic foundation for instructional planning. Differences between Field Independent and Field Dependent learners are analyzed not to predict achievement disparities, but to illuminate potential variations in learning needs. Through this profiling perspective, the study contributes to geometry education research by shifting attention from post-treatment effectiveness to pre-instructional diagnosis. Such an approach positions cognitive style as an informative lens for aligning instructional design with learners' actual characteristics, thereby supporting more responsive, context-sensitive geometry learning environments. It is expected that the findings will support the development of more adaptive, inclusive, and cognitively responsive geometry learning environments, while also providing a basis for future experimental and longitudinal research on instructional design.

2. METHOD

Research Design

This study employed a descriptive survey design with comparative analysis to map students' creative thinking profiles in geometry and to identify instructional needs emerging from cognitive style differences. The research was diagnostic rather than interventional, meaning that no instructional treatment was introduced during data collection. Instead, the study focused on documenting baseline creative thinking structures prior to any pedagogical modification. Students' cognitive styles were identified using the Group Embedded Figures Test (GEFT), which classifies individuals into Field Independent (FI) and Field Dependent (FD) categories based on their ability to disembed simple figures from complex visual backgrounds. Creative thinking was measured using the Creative Thinking in Geometry Test (CTGT), scored using a 1–5 rubric across four dimensions: fluency, flexibility, originality, and elaboration. This orientation responds to the tendency in recent studies to emphasize post-intervention improvements, while giving comparatively less attention to students' initial cognitive configurations.

Research Site and Participants

The study was conducted at UIN Siber Syekh Nurjati Cirebon within a geometry-related course emphasizing spatial reasoning and three-dimensional concepts. Participants were drawn from two intact undergraduate classes: 32 students in Class A and 30 in Class B, for a total of 62 participants. Both classes followed the same syllabus, learning objectives, instructional schedule, and assessment framework to ensure contextual equivalence during data collection. Students were classified into Field Independent (FI) and Field Dependent (FD) categories using a standardized cognitive style instrument. The distribution of cognitive style categories was examined descriptively to ensure analytical balance across classes before further comparison was conducted.

Instruments

Three instruments were administered in this study. The Creative Thinking in Geometry Test (CTGT) was designed to measure four dimensions of mathematical creative thinking: fluency, flexibility, originality, and elaboration, consistent with contemporary creativity frameworks in mathematics education [2]. Test items consisted of open-ended geometry problems requiring spatial visualization, representational transformation, and multiple-solution reasoning. The use of open-ended tasks aligns with findings that divergent problem scenarios stimulate creative engagement [7] and that creativity contributes meaningfully to problem-solving performance [5]. Responses were scored using an analytic rubric that allowed separate evaluation of each dimension.

A standardized cognitive style instrument was used to classify students into FI and FD groups. Cognitive style functioned as a grouping variable for comparative analysis rather than as a predictive construct. In addition, a short geometry achievement measure was administered to provide contextual information regarding students' conceptual and procedural understanding, acknowledging the interdependence of these domains in mathematical reasoning [14].

Validity and Reliability

Content validity was established through expert review by mathematics education specialists who evaluated the alignment of test items with geometry constructs and creative thinking indicators. Revisions were made based on feedback to ensure clarity and construct representation. Internal consistency reliability was assessed using Cronbach's alpha prior to full data analysis, and all instruments met acceptable reliability standards for educational research.

Data Collection Procedure

Data collection was conducted during the early phase of the semester before the introduction of any instructional innovation in either class. The cognitive style instrument

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was administered first to avoid potential influence from the creative task. The Creative Thinking followed this in the Geometry Test and the geometry achievement measure. Both classes completed the instruments under comparable classroom conditions to minimize contextual bias.

Data Analysis

Data analysis proceeded in four stages. First, descriptive statistics, including means, standard deviations, and distribution patterns, were calculated for each creative thinking dimension across the total sample and within each class to construct baseline profiles. Second, class equivalence was examined using independent-samples t-tests to determine whether significant differences existed between Class A and Class B. In the absence of significant differences, data from both classes were combined for subsequent analysis. Third, independent-samples t-tests were conducted to examine differences in creative thinking dimensions between the FI and FD groups, with effect sizes (Cohen's d) reported to assess practical significance. Finally, instructional needs were identified by interpreting dimensions with consistently lower mean scores or substantial variation across cognitive style groups as priority areas for pedagogical alignment.

Through this structure, the method maintains a clear diagnostic focus, positioning creative thinking in geometry as a mapped cognitive profile rather than an intervention outcome, while situating cognitive style as a lens for identifying differentiated instructional needs within the institutional context.

3. RESULTS AND DISCUSSION

1) Baseline Profile of Students' Creative Thinking in Geometry

The initial analysis focused on mapping the distribution of students' creative thinking abilities in the context of geometry learning. Four dimensions were examined separately fluency, flexibility, originality, and elaboration, separately, to identify how patterns of creative thinking appeared at the baseline stage prior to any pedagogical intervention. Descriptive statistics for each dimension are presented in Table 1.

Table 1. Descriptive Statistics of Students' Creative Thinking in Geometry (N = 62)

Dimension	**Mean**	**SD**	**Min**	**Max**	**Category**
Fluency	3.42	0.78	2.00	5.00	Moderate
Flexibility	3.15	0.81	1.80	4.80	Moderate
Originality	2.89	0.84	1.60	4.60	Moderate–Low
Elaboration	3.05	0.76	1.90	4.70	Moderate

The results indicate that students' creative thinking abilities in geometry were not evenly distributed across the four dimensions. Fluency emerged as the dimension with the highest mean score, suggesting that many students could generate several possible approaches when faced with open-ended geometry problems. In many responses, students attempted more than one method before settling on a final solution.

For example, one student approached a three-dimensional geometry problem involving the volume of a composite solid by exploring two possible strategies:

"First, I divided the shape into two triangular prisms and calculated the volumes separately. After that, I tried another way by transforming the solid into a prism and subtracting the small pyramid part." (Student S17)

This response illustrates the tendency to generate multiple solution paths, a characteristic commonly associated with fluency in mathematical creativity. Similar patterns appeared in several students' responses, in which the initial stage of problem-solving involved experimenting with multiple representations or decompositions of the geometric object.

However, the presence of multiple ideas did not always correspond to comparable levels of strategic diversity. The mean scores for flexibility and elaboration remained within the moderate range. Some students were able to shift from one representation to another, for instance, from a geometric decomposition to a formula-based calculation, but these transitions were not consistently observed across the dataset. In several cases, students relied on variations of the same procedural approach rather than fundamentally different strategies.

This tendency becomes clearer in the dimension of originality, which recorded the lowest mean score among the four indicators. Many solutions followed common procedural patterns typically introduced in classroom instruction. One student's response illustrates this pattern:

"I changed the shape into two triangular prisms and then used the volume formula for each prism before adding them together." (Student S08)

`Although mathematically correct, the strategy reflects a conventional transformation frequently used in geometry problem solving. Only a limited number of students attempted fewer common approaches, such as reinterpreting the solid through alternative spatial perspectives or constructing auxiliary geometric elements to simplify the structure.

Taken together, these patterns suggest that students were relatively capable of producing several initial ideas when solving geometry problems, yet the diversity and novelty of these ideas were less pronounced. In other words, the creative process appeared to emphasize the quantity of generated solutions more than the uniqueness or transformation of strategies. This baseline pattern provides an important diagnostic insight: while students demonstrate emerging fluency in generating ideas, the dimension of originality may represent a priority area for instructional development in geometry learning contexts.

2) Class Equivalence Analysis

Before proceeding to further analysis, it was necessary to ensure that the two classes used as data sources were comparable at the baseline. Establishing equivalence between groups is important in diagnostic studies because it helps confirm that observed patterns reflect the overall student population rather than the characteristics of a particular class. To
4 examine this condition, an independent samples t-test was conducted to compare the creative thinking scores of students in Class A and Class B across the four measured dimensions.

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Table 2. Independent Samples t-Test for Creative Thinking Between Classes

Dimension	Class A Mean	Class B Mean	t	p	Interpretation
Fluency	3.45	3.38	0.41	.684	Not significant
Flexibility	3.18	3.11	0.36	.721	Not significant
Originality	2.92	2.85	0.38	.705	Not significant
Elaboration	3.08	3.01	0.40	.690	Not significant

The results of the class equivalence test indicate that no statistically significant differences were found between Class A and Class B across all dimensions of creative thinking. The *p*-values for fluency, flexibility, originality, and elaboration all exceeded the .05 significance threshold, suggesting that the observed differences in mean scores were minimal and statistically negligible.

A closer examination of students' written responses also supports this statistical pattern. In both classes, students tended to approach geometry tasks using similar procedural strategies. For instance, when solving a problem involving the volume of a composite solid, students from both classes frequently relied on geometric decomposition as their primary strategy.

One student from Class A wrote:

"I separated the shape into a prism and a pyramid, calculated the volume of each part, and then added them to get the total volume." (Student A12)

A comparable approach appeared in responses from Class B:

"The solid can be divided into two simpler shapes. After finding the volume of each one using the formula, the results are combined to obtain the final answer." (Student B07)

Although the wording differed slightly, the structure of reasoning remained largely consistent across both groups. Students typically begin by simplifying the geometric structure into familiar shapes before applying standard formulas. This similarity in problem-solving orientation reinforces the statistical finding that both classes demonstrated comparable baseline creative thinking profiles.

From a methodological perspective, the absence of significant differences between the two classes allows the dataset to be treated as a single analytical sample in subsequent analyses. Consequently, the creative thinking profile constructed in this study does not represent the characteristics of a specific class but rather reflects the broader cognitive tendencies of students engaged in geometry learning within the institutional context.

3) Creative Thinking Differences Based on Cognitive Style

The subsequent analysis focused on examining differences in creative thinking abilities between students with Field Independent (FI) and Field Dependent (FD) cognitive styles. Cognitive style was treated as a grouping variable to examine whether variations in information-processing tendencies were reflected in how students approached open-ended geometry problems. Independent samples t-tests were conducted to compare the mean scores of the two groups across the four creative thinking dimensions.

Table 3 Differences in Creative Thinking Based on Cognitive Style

Dimension	**FI Mean**	**FD Mean**	**t**	**p**	**Cohen's d**
Fluency	3.61	3.20	2.14	.036	0.54
Flexibility	3.42	2.89	2.76	.008	0.69
Originality	3.05	2.67	2.01	.049	0.51
Elaboration	3.18	2.91	1.53	.131	0.39

The comparison based on cognitive style revealed a relatively consistent pattern. Students categorized as Field Independent obtained higher mean scores across nearly all dimensions of creative thinking compared to those categorized as Field Dependent. Statistically significant differences were observed in fluency, flexibility, and originality, while the difference in elaboration did not reach the conventional level of statistical significance.

A closer look at students' written solutions provides further insight into these statistical differences. In many cases, FI students demonstrated a tendency to reorganize geometric structures and consider alternative representations when solving spatial problems. For instance, one FI student approached a problem involving the volume of a complex solid by first reconstructing the geometric structure conceptually:

> *"Instead of directly applying the volume formula, I imagined the solid as a cube with a pyramid removed from the top. So I calculated the cube first, then subtracted the pyramid volume to find the remaining part." (Student S21, FI)*

This response reflects an analytical restructuring of the geometric object, indicating the ability to detach from the given representation and reinterpret the problem through a different spatial configuration. Such transformations were frequently associated with higher scores in flexibility and originality.

In contrast, several FD students tended to rely more closely on the visual structure presented in the problem statement. Their solutions often followed the most immediately recognizable decomposition strategy. For example, one student explained the solution as follows:

> *"I divided the shape into parts that look like prisms and calculated each volume using the usual formula. After that, I added the results to get the total volume." (Student S34, FD)*

While this strategy demonstrates correct procedural reasoning, the approach typically remained within familiar solution patterns. FD students were generally able to elaborate on the given structure once a solution pathway was identified, but fewer responses showed attempts to reinterpret the geometric configuration in fundamentally different ways.

The pattern suggests that FI students may be more inclined to reorganize spatial information and explore alternative representations, leading to a wider range of solution strategies in open-ended geometry tasks. FD students, on the other hand, often demonstrated stable procedural reasoning but engaged less frequently in restructuring the problem context.

Importantly, these findings should not be interpreted as indicating the superiority of one cognitive style over another. Rather, they illustrate how different cognitive processing tendencies may shape students' engagement with geometry problems that require exploratory thinking. From an instructional perspective, this variation highlights the potential need for differentiated learning activities. In particular, learning environments that explicitly encourage strategy exploration and multiple representations may help support students whose cognitive tendencies align more closely with Field Dependent processing styles.

4) Distribution of Cognitive Styles

An initial step in the analysis involved examining the distribution of cognitive styles within the sample. Understanding this distribution is important because meaningful comparisons between Field Independent (FI) and Field Dependent (FD) students are possible only when both groups are sufficiently represented in the dataset. The classification of students into FI and FD categories was based on results from the standardized cognitive style instrument administered at the start of data collection.

Table 4. Distribution of Students Based on Cognitive Style (N = 62)

Cognitive Style	**Frequency**	**Percentage**
Field Independent (FI)	34	54.8%
Field Dependent (FD)	28	45.2%
Total	**62**	**100%**

The distribution of cognitive styles indicates that the two categories were relatively balanced within the research sample. Students classified as Field Independent slightly outnumbered those categorized as Field Dependent, yet the difference in proportion remained relatively small. This composition provides an adequate basis for comparative analysis because neither group dominates the dataset to an extent that would distort statistical interpretation.

Evidence from the cognitive style test responses also reflected noticeable variation in how students processed visual information embedded in geometric structures. For example, in one item requiring students to identify a simple geometric figure hidden within a more complex visual arrangement, FI students often isolated the target structure by mentally separating it from the surrounding configuration. One FI student noted:

> *"I ignored the outer lines first and focused only on the triangle that appears inside the figure. After that, it became easier to recognize the shape." (Student S11, FI)*

In contrast, several FD students tended to describe the figure as a whole before identifying its internal components. A response from an FD student illustrates this orientation:

> *"At first, the picture looks complicated because all the lines are connected. I tried to follow the lines one by one until I found the triangle inside." (Student S29, FD)*

These contrasting descriptions do not necessarily indicate differences in correctness, but they illustrate distinct tendencies in how visual information is organized during problem solving. FI students frequently approached the task by isolating structural elements from the surrounding context, while FD students often processed the configuration more holistically before identifying its internal components.

From a diagnostic perspective, this distribution suggests that diversity in cognitive processing styles is naturally present within the geometry classroom. In other words, the learning environment does not consist of a cognitively homogeneous group of learners. Such variation highlights the potential importance of instructional approaches that accommodate different ways of interpreting and reorganizing spatial information. Recognizing this diversity may therefore contribute to the development of learning environments that are more responsive to the range of cognitive tendencies present among students.

5) Creative Thinking Profile Categories

Beyond examining mean scores, mapping the distribution of ability levels provides a clearer picture of how creative thinking is distributed among students. Categorizing scores into low, moderate, and high levels allows the analysis to capture variation across the student population rather than relying solely on central tendencies. The categories were determined based on score intervals defined in the analytic scoring rubric used for the Creative Thinking in Geometry Test (CTGT).

Table 5. Distribution of Creative Thinking Levels in Geometry

Dimension	**Low**	**Moderate**	**High**
Fluency	11 (17.7%)	36 (58.1%)	15 (24.2%)
Flexibility	15 (24.2%)	34 (54.8%)	13 (21.0%)
Originality	20 (32.3%)	30 (48.4%)	12 (19.3%)
Elaboration	16 (25.8%)	33 (53.2%)	13 (21.0%)

The distribution of categories indicates that the majority of students fall within the moderate level across nearly all dimensions of creative thinking. This pattern suggests that while students demonstrate emerging creative capacities in geometry problem solving, these abilities have not yet developed consistently at higher levels across the cohort.

Among the four dimensions, fluency shows a relatively higher proportion of students in the high category than the other indicators. This pattern suggests that many students generated more than one possible idea when confronted with open-ended geometry problems. For example, one student attempted two different approaches to determine the volume of a composite solid:

> *"First, I tried calculating the volume by separating the solid into two triangular prisms. Then I checked another way by imagining the solid as a larger prism with a small pyramid removed." (Student S14)*

Such responses illustrate the ability to generate multiple potential pathways before confirming a final solution, a characteristic typically associated with fluency in mathematical creativity.

A different pattern emerges in the originality dimension. This indicator shows the highest proportion of students in the low category compared with the other dimensions. Although students were often able to produce several solution steps, many of these approaches followed familiar procedural strategies commonly used in geometry instruction. One example reflects this tendency:

> *"The shape can be divided into a prism and a pyramid, so I used the usual formulas for each part and added the results." (S26)*

While mathematically valid, this strategy reflects a routine decomposition method frequently introduced in classroom practice. Only a small portion of responses demonstrated attempts to reinterpret the geometric structure through less common perspectives, such as constructing auxiliary lines or redefining the solid's spatial orientation.

The contrast between these patterns suggests that students are generally capable of generating several solution ideas, yet these ideas often remain within conventional procedural boundaries. In other words, the creative process observed in this dataset appears to emphasize the generation of multiple solutions rather than the development of novel or unconventional strategies.

From a diagnostic perspective, this gap highlights an instructional priority. If creative thinking in geometry is expected to involve not only the production of ideas but also the transformation of representations and strategies, then learning activities that encourage alternative spatial interpretations, multiple representations, and non-routine problem exploration may need to be more deliberately integrated into geometry instruction.

Discussion

The present study aimed to diagnose students' creative thinking profiles in geometry and examine how these profiles vary across cognitive styles prior to the implementation of instructional innovation. The findings reveal several interconnected patterns. First, students' creative thinking abilities were unevenly distributed across the four dimensions of fluency, flexibility, originality, and elaboration. Second, cognitive style differences appeared to influence how students approached open-ended geometry tasks. Third, most students demonstrated moderate levels of creative thinking, with originality emerging as the weakest dimension. These patterns provide insight into the baseline cognitive conditions that may shape how students respond to future instructional interventions in geometry learning.

The first major finding concerns the uneven distribution of creative thinking dimensions. Students demonstrated relatively stronger fluency than originality, indicating that they were generally able to generate multiple solution ideas but less likely to produce novel or unconventional strategies. This pattern reflects a common trajectory in mathematical creativity, in which idea generation develops earlier than the capacity to transform or reinterpret problem structures [15]. Previous research has similarly noted that creative thinking in mathematics is often expressed initially through the production of multiple ideas before evolving toward more sophisticated forms of originality and strategic transformation [1], [7]. Studies examining technology-enhanced learning environments have shown that when students are provided with interactive visual tools, improvements in creativity tend to occur more evenly across fluency, flexibility, originality, and elaboration [2], [3]. Augmented reality environments, for instance, allow learners to interact with three-dimensional objects from multiple spatial perspectives, enabling them to experiment with alternative interpretations of geometric structures [2], [4]. The relatively lower originality observed in the present study may therefore reflect the limited opportunities students have had to explore geometry problems through interactive visualization or exploratory reasoning environments. This suggests that originality is not merely an individual deficit but may be structurally shaped by prior learning experiences that constrain opportunities for representational experimentation.

The moderate performance observed in flexibility and elaboration also reflects the procedural orientation commonly found in geometry instruction. In many responses, students were able to expand or clarify their reasoning once a solution pathway had been identified, yet fewer students demonstrated the ability to reinterpret the geometric configuration through fundamentally different representations. Such patterns are consistent with research indicating that mathematics classrooms often emphasize procedural accuracy and formula application rather than exploratory reasoning [12], [14]. Conceptual and procedural knowledge operate interdependently in mathematical reasoning, yet an instructional emphasis on procedural fluency may limit students' opportunities to engage in deeper representational transformation [14], [16]. Studies on dynamic geometry environments have shown that tools such as GeoGebra can support the transition from procedural reasoning toward conceptual exploration by enabling students to manipulate geometric relationships directly [10], [11]. These findings suggest that the development of flexibility and originality in geometry may depend not only on students' cognitive abilities but also on the availability of learning environments that encourage experimentation with spatial representations.

The role of cognitive style also emerged as an important factor shaping students' creative thinking performance. Students categorized as Field Independent consistently demonstrated higher scores in fluency, flexibility, and originality compared with Field Dependent students [17], [18], [19]. Within the context of open-ended geometry tasks in the Creative Thinking in Geometry Test (CTGT), these differences became apparent when students were required to reinterpret spatial structures or reconstruct geometric configurations during problem-solving. This finding contributes theoretically by positioning cognitive style as a mediating lens in creative thinking processes, linking perceptual restructuring with divergent problem-solving behavior in geometry contexts. Field Independent learners tended to isolate structural elements from the visual context and reorganize them into alternative representations, a tendency that facilitated the exploration of multiple solution pathways. In contrast, Field Dependent students often relied more closely on the structure initially presented in the problem and followed solution strategies that resembled familiar classroom procedures.

These differences reflect broader theoretical perspectives on cognitive processing in complex learning environments. Research in mathematics education suggests that learners vary in how they interpret and reorganize visual information during spatial reasoning tasks, and these variations may influence their engagement in exploratory problem-solving [20], [21]. In environments that require analytical restructuring of visual information, such as open-ended geometry tasks, Field Independent learners may be more inclined to experiment with alternative representations of geometric structures. However, cognitive performance in such contexts cannot be attributed solely to individual characteristics. Contemporary research in STEM education emphasizes that cognitive development emerges from the interaction between learners and the instructional environments in which they participate [9], [22], [23]. Consequently, differences observed between FI and FD learners should be interpreted not as fixed ability gaps but as reflections of how different cognitive orientations interact with the structure of learning tasks and instructional conditions.

The interaction between cognitive style and task design is particularly relevant in problem-centered learning environments. Studies on Problem-Based Learning have shown that open-ended and inquiry-oriented problem contexts can significantly strengthen students' creativity and problem-solving abilities [5], [6]. However, the impact of such approaches is often uneven across cognitive domains, with creativity and problem-solving benefiting more strongly than other cognitive skills [5]. Open-ended problem scenarios encourage students to explore multiple solution pathways and engage in divergent thinking processes [7]. Collaborative problem-solving environments further support creative engagement by allowing learners to observe peers' alternative strategies and refine their reasoning through discussion [8], [24]. These findings suggest that instructional environments designed to emphasize exploration, collaboration, and multiple representations may help support students whose cognitive tendencies align more closely with Field Dependent processing patterns. This suggests that instructional design can either amplify or mitigate cognitive style differences, positioning pedagogy as an active factor in shaping creative engagement rather than a neutral medium.

Another important pattern emerging from the present study concerns the overall distribution of creative thinking levels. The majority of students were categorized as moderate across all four creativity dimensions. This distribution suggests that students possess emerging creative capacities but have not yet consistently developed them into higher-level creative reasoning. In geometry learning contexts, this developmental stage may reflect the complexity of spatial reasoning tasks that require integrating visualization, conceptual understanding, and procedural knowledge [21], [25]. Research grounded in Van Hiele theory [26] indicates that students' geometric reasoning develops progressively through stages, beginning with visual recognition and advancing toward abstract deductive reasoning [12], [13]. Technology-enhanced instructional approaches have been shown to support this progression by strengthening conceptual understanding at intermediate levels of abstraction [10]. However, without targeted opportunities for exploration and restructuring, students may remain at transitional levels of creative development rather than progressing toward more advanced reasoning.

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Taken together, these findings highlight the importance of diagnosing students' cognitive conditions prior to implementing instructional innovations in geometry learning. Much of the existing research in mathematics education focuses on evaluating the effectiveness of new pedagogical approaches, such as augmented reality environments, dynamic geometry software, or problem-based learning models [2], [5], [10]. While these studies provide valuable evidence regarding the potential benefits of innovative instructional designs, they often assume relatively homogeneous learner characteristics at the outset of instruction. The present study suggests that students enter geometry learning environments with diverse creative thinking profiles shaped by differences in cognitive processing tendencies and prior learning experiences. This shifts the analytical focus from instructional impact alone toward the interaction between initial cognitive conditions and pedagogical design.

From this perspective, the contribution of the present study lies in shifting attention from post-intervention effectiveness toward pre-instructional diagnosis. By mapping students' creative thinking profiles before implementing pedagogical innovations, educators and researchers can gain a clearer understanding of where instructional support is most needed. Such diagnostic insight can inform the design of learning environments that encourage exploration, multiple representations, and spatial experimentation conditions that previous research has identified as critical for the development of mathematical creativity in geometry learning contexts [2], [3], [4]. The study thus contributes theoretically by integrating creative thinking and cognitive style within a diagnostic framework, positioning baseline cognition as a critical reference point for instructional design rather than a background variable.

Despite these contributions, several limitations should be acknowledged. The sample was relatively small and drawn from a single institutional context, which may limit the transferability of findings. The cross-sectional design captures students' profiles at one point in time and does not account for developmental changes. In addition, the use of structured test instruments may not fully capture creative thinking as it occurs in authentic, dynamic problem-solving situations. These constraints indicate the need for longitudinal and multi-context investigations that incorporate more process-oriented measures of creativity.

4. CONCLUSION

This study maps students' creative thinking profiles in geometry and examines how these profiles vary across cognitive styles within a university learning context. Rather than reiterating specific score patterns, the study highlights a key insight: students enter geometry learning with differentiated cognitive configurations that shape how they engage with problem-solving tasks. From this perspective, creative thinking is not merely an outcome of instruction but a pre-instructional condition that influences the direction and effectiveness of pedagogical design.

The implications of these findings lie in the need to integrate diagnostic profiling into instructional planning. Recognizing variation in creative thinking and cognitive style allows educators to design learning environments that are more adaptive, exploratory, and responsive to diverse cognitive tendencies. At the same time, this study is constrained by

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several limitations, including a relatively small, context-specific sample, a cross-sectional design that does not capture developmental change, and the use of structured instruments that may not fully capture creative thinking in authentic contexts.

Future research should extend this work through experimental and longitudinal approaches. Experimental studies can examine how specific instructional strategies interact with cognitive styles, while longitudinal research can trace the development of creative thinking over time. Expanding to broader contexts and incorporating qualitative perspectives would strengthen the explanatory depth of future findings. More broadly, this study advances a diagnostic perspective that links cognitive characteristics to instructional design, offering a foundation for more inclusive and context-sensitive geometry learning practices.

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