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Implementing Differentiated Instruction in Quadrilateral Learning to Support Mathematical Conceptual Understanding

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Abstract

Developing students' mathematical conceptual understanding in geometry remains challenging because students with different cognitive styles construct concepts through different learning processes, while differentiated instruction has rarely been examined from this perspective. This study investigated the implementation of differentiated instruction in quadrilateral learning and explored the conceptual understanding of Field Independent (FI) and Field Dependent (FD) students. A qualitative descriptive design involved 28 Grade VII-C students. The Group Embedded Figures Test (GEFT) classified cognitive styles, and four participants (two FI and two FD) were selected for in-depth analysis using a conceptual understanding test, semi-structured interviews, and classroom observations. The findings showed that differentiated instruction supported conceptual understanding through learning pathways aligned with students' cognitive characteristics. FI students demonstrated more analytical reasoning, whereas FD students benefited from visual representations, structured worksheets, and teacher scaffolding. These findings extend differentiated instruction research by integrating cognitive style and provide practical guidance for adaptive geometry instruction.

Keywords: *differentiated instruction; mathematical conceptual understanding; cognitive style; geometry education; Field Independent; Field Dependent*

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INTRODUCTION

Recent evidence indicates that students continue to experience difficulties in developing mathematical conceptual understanding, particularly in geometry. International large-scale assessments consistently show that many students struggle with mathematical reasoning, problem solving, and the application of concepts in unfamiliar situations. Similar findings have been reported in Indonesia, where students frequently experience misconceptions in geometry because they rely on memorizing formulas rather than understanding relationships among mathematical concepts (Murtinasari & Lutfiyah, 2022; Purwati & Yulianti, 2023). Such conditions indicate that strengthening mathematical conceptual understanding remains a major challenge in mathematics education. Conceptual understanding enables students to interpret mathematical ideas, connect multiple representations, and apply knowledge flexibly in problem-solving situations, making it one of the fundamental goals of mathematics learning (Kilpatrick et al., 2001; NCTM, 2000). This issue is particularly important in learning quadrilaterals, where students are expected to recognize geometric properties, classify figures, and understand hierarchical relationships among quadrilaterals.

Students' conceptual understanding is influenced not only by instructional practices but also by their cognitive characteristics. One important cognitive dimension is the distinction between Field Independent (FI) and Field Dependent (FD) cognitive styles. FI students generally process information analytically and construct mathematical concepts independently, whereas FD students tend to rely on external guidance, contextual information, and social interaction during learning (Anggraeni et al., 2021;Asmaun, 2024). Previous studies have also shown that students continue to experience conceptual difficulties in various mathematical topics because learning is often dominated by procedural instruction rather than conceptual exploration (Rohim, 2022). Moreover, students' logical thinking and logical-mathematical intelligence are closely related to conceptual understanding and mathematical problem solving (Anita et al., 2024; Rohim & Prayogi, 2023). These findings suggest that differences in cognitive characteristics should be considered when designing mathematics instruction. One instructional approach that accommodates learner diversity is differentiated instruction, which adapts learning content, processes, products, and instructional support according to students' readiness, interests, and learning profiles (Tomlinson, 2022). Consistent with constructivist learning theory and the principles of the Merdeka Curriculum, differentiated instruction provides flexible learning experiences that enable students to construct mathematical understanding according to their individual needs (Faiz et al., 2022).Previous studies have reported that differentiated instruction improves students' engagement and conceptual understanding in mathematics learning (Ambarini et al., 2024a; Ilmiyah et al., 2024; Malehere & Listiani, 2024)

Although differentiated instruction has been widely discussed, several research gaps remain. Previous studies have generally examined its effects on mathematics achievement or conceptual understanding without considering students' cognitive styles. Conversely, studies on Field Independent and Field Dependent learners have mainly described differences in students' conceptual understanding without explaining how differentiated instructional practices accommodate these differences. In addition, studies on quadrilateral learning have largely focused on misconceptions, learning outcomes, or geometric reasoning rather than on how students construct conceptual understanding within differentiated learning environments (Naiya, 2025). Therefore, limited evidence is available regarding the interaction between differentiated instruction, cognitive style, and mathematical conceptual understanding in geometry learning.

Based on these gaps, this study investigates the implementation of differentiated instruction in quadrilateral learning and explores the mathematical conceptual understanding demonstrated by students with Field Independent and Field Dependent cognitive styles. The novelty of this study lies in integrating differentiated instruction, cognitive style, and mathematical conceptual understanding within a qualitative analysis of quadrilateral learning. The findings are expected to contribute theoretically to the development of mathematics education by extending the application of differentiated instruction from cognitive style perspectives and practically by providing guidance for mathematics teachers in designing adaptive learning that accommodates students' diverse cognitive characteristics.

METHODS

Research Design

This study employed a qualitative descriptive design to obtain an in-depth description of students' mathematical conceptual understanding of quadrilaterals following the implementation of differentiated instruction. This design was considered appropriate because the study aimed to describe and interpret students' conceptual understanding and reasoning processes in their natural classroom context rather than to develop theory or investigate a bounded case. Unlike qualitative case study or interpretive case study designs, which emphasize comprehensive exploration of a particular case or participants' lived experiences, qualitative descriptive research focuses on providing a straightforward yet rich description of a phenomenon based directly on empirical data. Consequently, this approach enabled the researchers to examine students' written responses and verbal explanations while maintaining close alignment with the research objectives (Sandelowski, 2000; Colorafi & Evans, 2016).

The study was conducted in Grade VII-C of MTs Putra Putri Simo, Lamongan, Indonesia, during the second semester of the 2025/2026 academic year. The class consisted of 28 students with heterogeneous academic abilities and learning characteristics, providing an appropriate setting for implementing differentiated instruction.

Participants

Participants were selected using purposive sampling. Initially, all twenty-eight students completed the Group Embedded Figures Test (GEFT) to identify their cognitive styles. Based on the GEFT scores, students were classified into Field Independent (FI) and Field Dependent (FD) categories according to the classification proposed by Witkin et al. (1971), in which scores ranging from 0–11 indicate Field Dependent learners and scores between 12–18 indicate Field Independent learners.

Following this classification, four participants, consisting of two FI students and two FD students, were selected for in-depth analysis. The relatively small number of participants is consistent with the purpose of qualitative descriptive research, which prioritizes obtaining rich and comprehensive information rather than statistical generalization. Participant selection was based on their representation of each cognitive style category, their ability to communicate mathematical reasoning during interviews, and the completeness of their written responses. Although recommendations from the mathematics teacher were considered to identify students who were willing and able to participate actively in interviews, the final selection was determined primarily by the GEFT classification and conceptual understanding test results, thereby reducing potential selection bias. Data collection was concluded when information obtained from interviews became repetitive and no substantially new findings emerged, indicating that sufficient information had been obtained to address the research objectives.

Differentiated Instruction Implementation

The differentiated instruction intervention was implemented by the researcher during three instructional meetings, each consisting of two 40-minute lesson periods. The instructional sequence covered the entire quadrilateral unit, including the classification, properties, perimeter, and area of quadrilaterals.

The instructional design followed Tomlinson's Differentiated Instruction framework by adapting learning experiences according to students' readiness and learning profiles (Tomlinson, 2022). Content differentiation was implemented through learning materials with different levels of complexity, while process differentiation was achieved by providing learning activities suited to students' cognitive characteristics. Students identified as Field Independent were encouraged to complete exploratory tasks requiring independent reasoning, multiple solution strategies, and conceptual connections among quadrilateral properties. This approach is consistent with the characteristics of Field Independent learners, who tend to analyze information independently, restructure knowledge, and perform better in tasks requiring analytical and self-directed problem solving (Witkin et al., 1977). In contrast, Field Dependent students received structured worksheets containing visual representations, guided questions, and step-by-step scaffolding to facilitate conceptual construction. These supports align with the characteristics of Field Dependent learners, who generally benefit from external guidance, structured learning environments, and visual or social support when processing information (Witkin et al., 1977). Although learning activities differed according to students' needs, all students were expected to achieve the same learning objectives and completed the same mathematical conceptual understanding assessment at the end of the instructional sequence.

To ensure consistency throughout the intervention, separate lesson plans were developed for each differentiated learning pathway. The implementation of differentiated instruction was monitored using a classroom observation checklist completed independently by the classroom mathematics teacher and a peer observer. Their observations confirmed that the differentiated instructional activities were implemented consistently across all instructional meetings.

Table 1. Implementation of Differentiated Instruction in Quadrilateral Learning

Differentiation Component	Implementation in This Study	FI Students	FD Students
Content	Learning materials were adjusted according to students' readiness while maintaining the same learning objectives.	Exploratory Worksheet: Explain why every square is a rectangle but not every rectangle is a square. Construct a concept map showing the hierarchical relationships among quadrilaterals and justify each connection.	Illustrated Worksheet: Students are provided with labeled diagrams of a square, rectangle, rhombus, parallelogram, and trapezoid. They first identify the properties by completing a table (equal sides, parallel sides, right angles, diagonals), then answer guided questions such as Which figures have four right angles? and Which figure belongs to more than one category?
Process	Students completed learning activities according to their cognitive characteristics.	Open-ended Task: A city plans two park designs: Design A (rectangle 20 × 10 m) and Design B (rhombus with side 16 m and height 12 m). Compare the area, perimeter, and fencing cost, then justify which design is more efficient using mathematical reasoning.	Guided Worksheet: The same problem is divided into sequential steps: (1) Calculate the area of Design A, (2) Calculate the perimeter of Design A, (3) Repeat for Design B, (4) Compare the results using a table, (5) Which design requires less fencing cost? Explain your answer.
Learning profil	Learning support was adjusted according to	Students worked independently with minimal teacher	Students worked with teacher prompts (e.g., Which sides are parallel?,

Differentiation Component	Implementation in This Study	FI Students	FD Students
	students' cognitive styles.	guidance and were encouraged to explain conceptual relationships using their own reasoning.	What formula should be used?) and received visual cues and feedback before drawing conclusions.
Product	All students demonstrated conceptual understanding through the same written assessment and follow-up interview.	Students submit written explanations with mathematical justification and elaborate their reasoning independently during interviews.	Students complete the same written assessment but receive guiding questions during interviews to help explain their reasoning (e.g., Why did you choose this formula?, Which property helped you identify the shape?).

As shown in Table 1, differentiated instruction was implemented by adapting learning materials and learning activities according to students' readiness and cognitive characteristics while maintaining identical learning objectives. For example, FI students received exploratory tasks requiring them to analyse hierarchical relationships among quadrilaterals and justify multiple solution strategies, whereas FD students worked with illustrated worksheets containing visual representations, simplified explanations, and step-by-step guiding questions before solving the same concepts independently. Although all students completed the same mathematical conceptual understanding assessment, the instructional pathways differed according to their learning needs. This design enabled FI students to develop concepts through independent exploration while supporting FD students through structured scaffolding and visual guidance.

Research Instruments

Three instruments were employed in this study, namely the Group Embedded Figures Test (GEFT), a mathematical conceptual understanding test, and semi-structured interview guidelines. The GEFT, originally developed by Witkin et al. (1971), was used to identify students' cognitive styles. This study employed an Indonesian version of the original instrument that had previously undergone translation and adaptation for educational research and was considered appropriate for identifying Field Independent and Field Dependent learners.

Students' mathematical conceptual understanding was assessed using six essay questions developed according to six indicators of conceptual understanding, namely the ability to restate mathematical concepts, classify objects according to their properties, provide examples and non-examples, represent concepts mathematically while applying appropriate procedures, select suitable mathematical procedures, and apply concepts to solve contextual problems. Each item was designed to represent one primary indicator while allowing students to demonstrate multiple aspects of conceptual understanding during problem solving.

Semi-structured interviews were conducted after students completed the conceptual understanding test to obtain deeper insight into their reasoning processes. Each interview lasted approximately 30–45 minutes and was conducted individually by the researcher in a face-to-face setting. The interviews followed a set of guiding questions derived from each test item while allowing additional probing questions to explore participants' conceptual explanations, reasoning strategies, and decision-making processes. All interviews were video recorded and transcribed verbatim prior to analysis.

Before data collection, all research instruments were evaluated by three experts in mathematics education to assess content relevance, language clarity, and alignment with the research objectives. Revisions were made based on the validators' suggestions until all instruments were considered suitable for classroom implementation.

Table 2 Blueprint of the Mathematical Conceptual Understanding Test

Item	Indicator of Mathematical Conceptual Understanding	Quadrilateral Topic
Q1	Restating a mathematical concept	Definition and characteristics of quadrilaterals
Q2	Classifying objects based on their properties	Classification of quadrilaterals
Q3	Providing examples and non-examples	Properties of quadrilaterals
Q4	Representing concepts mathematically and applying procedures appropriately	Perimeter and area of quadrilaterals
Q5	Selecting and applying appropriate mathematical procedures	Solving quadrilateral problems
Q6	Applying concepts to solve contextual problems	Contextual quadrilateral problems

Table 2 presents the blueprint of the mathematical conceptual understanding test. Each essay question was developed to represent one primary indicator of conceptual understanding while allowing students to demonstrate multiple aspects of conceptual reasoning. The six items collectively covered the essential concepts of quadrilateral learning addressed during the differentiated instruction sessions.

Data Collection Procedure

Data collection was conducted in four consecutive stages. First, all students completed the Group Embedded Figures Test (GEFT) to identify their cognitive styles and classify them into Field Independent (FI) and Field Dependent (FD) categories. Second, differentiated instruction was implemented over three instructional meetings on quadrilateral topics. Throughout the instructional process, learning activities were adapted according to students' readiness and cognitive characteristics through differentiated content and learning processes. Third, all students completed the mathematical conceptual understanding test consisting of six essay questions.

Finally, four selected participants representing the FI and FD cognitive style categories participated in semi-structured interviews conducted after the written test. The interviews were intended to clarify students' written responses and to obtain deeper insights into their conceptual reasoning during problem solving. All interviews were video recorded, transcribed verbatim, and verified against the original recordings prior to analysis. The overall research procedure is illustrated in Figure 1.

Figure 1. Research Procedure

Data Analysis

The data were analyzed using the qualitative data analysis model proposed by Miles et al. (2014), consisting of data condensation, data display, and conclusion drawing. During the data condensation stage, students' written responses and interview transcripts were carefully reviewed, organized, and coded according to the indicators of mathematical conceptual understanding. The coding process combined deductive and inductive approaches. Deductive coding was initially conducted using predetermined indicators of mathematical conceptual understanding as the analytical framework, whereas inductive coding was subsequently employed to identify emerging patterns in students' reasoning that were not explicitly represented by the predetermined categories.

Coding was conducted manually by the researcher through repeated reading of students' written work and interview transcripts. Initial codes representing students' conceptual understanding and reasoning processes were generated during open coding. These codes were then refined and organized into broader conceptual categories through axial coding, enabling relationships among students' conceptual characteristics to be identified. Subsequently, broader themes describing the conceptual understanding profiles of Field Independent and Field Dependent students were developed. Finally, a cross-case comparison was performed to identify similarities and differences in conceptual understanding between participants representing the two cognitive style categories.

The analyzed data were subsequently presented descriptively by integrating evidence obtained from students' written responses and interview findings. Conclusions were drawn through continuous comparison between emerging findings and the theoretical framework of differentiated instruction, cognitive style, and mathematical conceptual understanding to ensure consistency throughout the interpretation process.

Trustworthiness

To enhance the trustworthiness of the findings, this study adopted the criteria proposed by Lincoln and Guba (1985), including credibility, transferability, dependability, and confirmability. Credibility was established through method triangulation by comparing data obtained from the GEFT, the mathematical conceptual understanding test, and semi-structured interviews. Prolonged engagement during three instructional meetings and repeated examination of interview transcripts further strengthened the credibility of the findings. Transferability was supported by providing detailed descriptions of the research context, participants, instructional procedures, and data collection process to enable readers to determine the applicability of the findings to similar educational contexts.

Dependability was ensured through a clearly documented research procedure, including the implementation of differentiated instruction, instrument development, interview procedures, and data analysis. Classroom observations conducted independently by the classroom teacher and a peer observer also confirmed that the differentiated instructional activities were implemented consistently throughout the intervention. Confirmability was established by maintaining an audit trail consisting of students' written responses, interview transcripts, observation records, coding documents, and field notes, allowing the research findings to be traced directly to the original empirical evidence rather than to researchers' personal interpretations.

Table 3. Observation Indicators for Differentiated Instruction Fidelity

Observed Aspect	Observation Indicator

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Learning objectives	Learning objectives were communicated clearly to all students.
Content differentiation	Learning materials were adjusted according to students' readiness.
Process differentiation	Learning activities differed according to students' cognitive characteristics.
Learning profile differentiation	Teacher provided appropriate support based on students' learning profiles.
Classroom interaction	Students actively participated in differentiated learning activities.
Lesson implementation	Learning activities followed the prepared lesson plans.

The implementation fidelity of differentiated instruction was monitored using the observation indicators presented in Table 3. Classroom observations were conducted independently by the mathematics teacher and a peer observer during each instructional meeting to ensure that the planned differentiated instructional strategies were implemented consistently.

Ethical Considerations

Prior to data collection, permission to conduct the study was obtained from the principal and mathematics teacher of MTs Putra Putri Simo. Participation was entirely voluntary, and informed consent was obtained from students and their parents or legal guardians before the research commenced. Participants were informed that all collected data would be used exclusively for research purposes and that their identities would remain confidential. To protect participants' privacy, pseudonyms and participant codes (A1, A2, A3, and A4) were used throughout the data analysis and reporting process.

RESULTS AND DISCUSSION

Cognitive Style Classification

The Group Embedded Figures Test (GEFT) was administered to all 28 students in Grade VII C to identify their cognitive styles. The cognitive style classification served as the basis for analysing differences in students' mathematical conceptual understanding following differentiated instruction. Based on the GEFT results, students were classified into two cognitive style categories: Field Independent (FI) and Field Dependent (FD).

Four participants were subsequently selected through purposive sampling for in-depth qualitative analysis, consisting of two FI students (A1 and A2) and two FD students (A3 and A4), as shown in Table 4. The selection considered three criteria: (1) representing each cognitive style category, (2) providing complete responses to the mathematical conceptual understanding test, and (3) demonstrating the ability to communicate mathematical reasoning clearly during semi-structured interviews.

Table 4. Cognitive Style Classification Based on GEFT

Participant	GEFT Score	Cognitive Style
A1	18	FI
A2	17	FI
A3	11	FD
A4	11	FD

Mathematical Conceptual Understanding

Analysis of the written responses and interview transcripts showed that both Field Independent (FI) students demonstrated relatively high mathematical conceptual understanding across the six indicators assessed. They accurately restated mathematical concepts, classified quadrilaterals according to their defining properties, provided appropriate examples and non-examples, represented concepts mathematically, selected appropriate procedures, and solved contextual problems using logical reasoning.

The strongest evidence was observed in the contextual problem-solving task, where FI students integrated multiple mathematical concepts before making a decision. Rather than focusing only on procedural calculations, they simultaneously considered area, perimeter, and fencing cost to determine the most efficient garden design. The transcription of FI-1's written response to Question 6 is presented below.

FI-1's Written Response (Question 6)
Design A
Area $= 20 \times 10 = 200\, m^2$
Design B
Area $= 16 \times 12 = 192\, m^2$
• Fencing Cost
Design A:
Perimeter $= 2(20 + 10) = 60\, m$
Cost $= 60 \times 60{,}000 = 3{,}600{,}000$
Design B:
Perimeter $= 4 \times 16 = 64\, m$
Cost $= 64 \times 60{,}000 = 3{,}840{,}000$
Conclusion:
Design A should be selected because its area is exactly 200 m^2 as required. In addition, its perimeter is shorter, resulting in a lower fencing cost.

FI-2 also demonstrated good conceptual understanding by correctly identifying the conceptual error presented in the problem and selecting the appropriate mathematical procedure. The student recognized that the land described in the problem was a rhombus rather than a square and successfully determined the correct area and the number of tiles required. During the interview, FI-2 stated, *"I first identified the properties of the figure. Since not all the angles are right angles, it cannot be a square, so I used the rhombus formula."* Compared with FI-1, FI-2 provided shorter explanations; however, the student consistently selected procedures based on conceptual understanding rather than memorization. The transcription of FI-2's written response to Question 5 is presented below.

FI-2's Written Response (Question 5)

Budi's mistake:

- Budi used the **area formula for a square**.
  $L = s^2$
  $L = 10^2 = 100\ m^2$

However, the shape is **not a square**.

Correct solution:

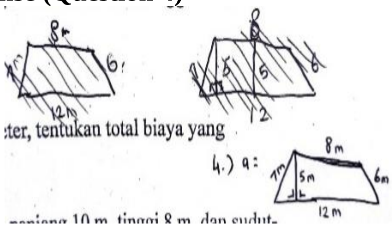
- Area of the rhombus:
  $L = a \times t$
  $L = 10 \times 8 = 80\ m^2$

Additional calculations:

- Perimeter:
  $K = 4 \times 10 = 40\ m$
- Area of one tile:
  $0.5 \times 0.5 = 0.25\ m^2$
- Number of tiles required:
  $\frac{80}{0.25} = 320\ tiles.$

Unlike the FI students, FD-1 demonstrated conceptual understanding through visual representation and teacher guidance. The student correctly sketched the trapezoid and accurately calculated its area, perimeter, and fencing cost. During the interview, FD-1 explained, *"At first, I was confused about which line represented the height. After the teacher asked guiding questions, I understood that the height is the distance between the two parallel sides."* These findings indicate that scaffolding and visual representation supported FD-1 in constructing mathematical concepts more effectively. The transcription of FD-1's written response to Question 4 is presented below.

FD-1's Written Response (Question 4)



Draw the trapezoid.

Given:

- Parallel sides = 12 m and 8 m
- Height = 5 m
- Other sides = 7 m and 6 m

Area:

$$L = \frac{1}{2}(a + b) \times t$$
$$L = \frac{1}{2}(12 + 8) \times 5$$
$$L = \frac{1}{2} \times 20 \times 5$$
$$L = 50\ \text{m}^2$$

Perimeter:

$$K = 12 + 6 + 7 + 8 = 33\ \text{m}$$

Total fencing cost:

$$33 \times 75{,}000 = 2{,}475{,}000$$

Similar characteristics were found in FD-2. The student correctly solved the contextual problem by comparing the area, perimeter, and fencing cost of the two proposed designs before selecting Design A as the most efficient alternative. During the interview, FD-2 stated, "I chose Design A because the fencing cost is lower and the area is larger." This response indicates that the student relied primarily on computational results rather than conceptual relationships among quadrilateral properties. Although FD-2 demonstrated adequate mathematical conceptual understanding, the findings suggest that the student's reasoning was strengthened through structured learning support, visual representation, and teacher scaffolding. The transcription of FD-2's written response to Question 6 is presented below.

FD-2's Written Response (Question 6)

Design A

Area $= 20 \times 10 = 200\ m^2$

Design B

Area $= 16 \times 12 = 192\ m^2$

- Fencing Cost

  Design A:

  Perimeter $= 2(20 + 10) = 60\ m$

  Cost $= 60 \times 60{,}000 = 3{,}600{,}000$

  Design B:

  Perimeter $= 4 \times 16 = 64\ m$

  Cost $= 64 \times 60{,}000 = 3{,}840{,}000$

Conclusion:

I choose Design A because the fencing cost is lower and the area is larger, making it more suitable.

Cross-Case Comparison of Mathematical Conceptual Understanding

Cross-case analysis revealed consistent differences between FI and FD students across all indicators of mathematical conceptual understanding.

Table 5. Cross-Case Comparison of Mathematical Conceptual Understanding between Field Independent and Field Dependent Students

Compared Aspect	Field Independent (FI-1 and FI-2)	Field Dependent (FD-1 and FD-2)
Restating concepts	Accurately restated the definition and characteristics of quadrilaterals using their own words and explained the relationships among concepts.	Correctly restated the basic definition of quadrilaterals, although the explanations tended to focus on the main characteristics.
Classifying quadrilaterals	Correctly classified quadrilaterals based on their properties and justified the classification using mathematical reasoning.	Correctly classified quadrilaterals but relied more on observable properties than conceptual relationships.
Examples and non-examples	Identified appropriate examples and non-examples and explained the reasons based on defining properties.	Distinguished examples from non-examples correctly, although the explanations were relatively brief.
Mathematical representation	Used appropriate mathematical representations to support reasoning and problem solving.	Relied on visual representations to facilitate understanding and solve problems correctly.
Selecting procedures	Selected solution procedures based on conceptual analysis before performing calculations.	Selected procedures after identifying relevant information, often supported by teacher guidance or structured learning materials.

Compared Aspect	Field Independent (FI-1 and FI-2)	Field Dependent (FD-1 and FD-2)
Contextual problem solving	Solved contextual problems systematically and provided logical mathematical justification for the selected solution.	Solved contextual problems correctly, but explanations emphasized computational results rather than conceptual relationships.

As shown in Table 5, FI students demonstrated greater independence in organizing conceptual relationships and justifying mathematical reasoning. In contrast, FD students showed stronger dependence on visual representations and teacher prompts when constructing mathematical concepts. Despite these differences, both cognitive style groups successfully demonstrated the indicators of mathematical conceptual understanding after participating in differentiated instruction.

Discussion

The present study revealed that students with Field Independent (FI) and Field Dependent (FD) cognitive styles demonstrated different patterns of mathematical conceptual understanding during quadrilateral learning implemented through differentiated instruction. FI students showed a more comprehensive understanding by independently connecting quadrilateral properties, organizing concepts hierarchically, and providing logical justifications for their mathematical decisions. In contrast, FD students generally relied on visual representations, teacher guidance, and structured questioning before they were able to explain conceptual relationships. These differences indicate that cognitive style influences not only students' learning outcomes but also the ways in which mathematical concepts are constructed and organized.

This interpretation is consistent with Witkin et al. (1977), who argued that Field Independent learners tend to process information analytically and organize knowledge through internal cognitive structures, whereas Field Dependent learners depend more on contextual information and external support. Similar results were reported by Anggraeni et al. (2021) and Asmaun (2024), who found that FI students generally demonstrate stronger analytical reasoning and more complete conceptual understanding in geometry learning than FD students. The consistency of these findings suggests that cognitive style plays an important role in determining how students establish relationships among geometric concepts. However, unlike previous studies that mainly described differences between cognitive styles, the present study further illustrates how these differences emerge within a differentiated instructional environment designed to accommodate diverse learner characteristics.

Although FI and FD students demonstrated different conceptual profiles, both groups benefited from the implementation of differentiated instruction. Rather than providing identical learning experiences, differentiated instruction created alternative learning pathways that enabled students to achieve the same conceptual objectives through instructional support appropriate to their cognitive characteristics. FI students developed understanding through exploratory activities requiring independent reasoning, whereas FD students strengthened their conceptual understanding through visual representations, guided worksheets, and teacher scaffolding. These results indicate that differentiated instruction does not eliminate differences in cognitive style but instead accommodates those differences by providing learning experiences that correspond to students' learning needs.

This finding supports Tomlinson's (2022) theory of differentiated instruction, which emphasizes adapting content, learning processes, and instructional support according to students' readiness, interests, and learning profiles. From a constructivist perspective, these results also reinforce the view that conceptual understanding develops through active interaction between learners and meaningful learning experiences. For FI students, conceptual construction occurred primarily through independent exploration, whereas FD students benefited more from structured guidance within their learning process. This pattern is also consistent with Vygotsky's concept of scaffolding, which explains that appropriate instructional support enables learners to construct higher levels of understanding than they could achieve independently.

The present findings are also consistent with previous studies reporting positive effects of differentiated instruction on mathematics learning. Ambarini et al. (2024) found that differentiated learning improved students' mathematical conceptual understanding, while Malehere and Listiani (2024) reported that adaptive instructional strategies increased students' engagement and conceptual achievement. Nevertheless, most previous studies evaluated differentiated instruction primarily through overall learning outcomes. In contrast, the present study provides a more detailed explanation of how students with different cognitive styles construct mathematical concepts during differentiated learning. Consequently, this study complements previous research by explaining the instructional mechanisms through which differentiated instruction supports conceptual understanding in geometry learning.

Overall, this study contributes to the literature by integrating differentiated instruction, cognitive style, and mathematical conceptual understanding within a single analytical framework. The findings suggest that cognitive style should be considered when designing differentiated mathematics instruction because students construct mathematical meaning through different cognitive pathways. Practically, the results encourage mathematics teachers to design learning activities that balance exploratory tasks for students who demonstrate greater learning independence with structured scaffolding for students requiring additional instructional support. Such instructional practices may help create more inclusive mathematics classrooms while promoting deeper conceptual understanding for learners with diverse cognitive characteristics.

CONCLUSION AND SUGGESTIONS

This study concludes that students with Field Independent (FI) and Field Dependent (FD) cognitive styles demonstrated different patterns of mathematical conceptual understanding during quadrilateral learning implemented through differentiated instruction. FI students showed greater independence in organizing conceptual relationships, selecting appropriate solution strategies, and providing logical mathematical justifications. In contrast, FD students demonstrated conceptual understanding more effectively when supported by visual representations, structured worksheets, and teacher scaffolding. Despite these differences, both cognitive style groups successfully achieved the expected indicators of mathematical conceptual understanding through learning experiences adapted to their cognitive characteristics. These findings indicate that differentiated instruction provides an effective instructional approach for accommodating diverse cognitive styles while enabling students to attain common learning objectives.

This study contributes to mathematics education by demonstrating that differentiated instruction not only supports students' mathematical conceptual understanding but also accommodates differences in how students construct mathematical knowledge according to their cognitive styles. Therefore, teachers should consider students' cognitive characteristics when designing differentiated mathematics instruction by balancing exploratory learning opportunities with appropriate instructional guidance.

This study has several limitations. First, the research involved only four participants selected for in-depth qualitative analysis from a single Grade VII class in one school, which limits the transferability of the findings to broader educational contexts. Second, the study focused exclusively on quadrilateral learning and examined students' mathematical conceptual understanding without investigating other mathematical abilities or the long-term effects of differentiated instruction.

Future research is recommended to involve a larger and more diverse sample from different schools and educational levels to enhance the transferability of the findings. Further studies may also investigate the implementation of differentiated instruction in other mathematical topics and examine its relationship with additional mathematical competencies, such as problem-solving, mathematical reasoning, communication, or creative thinking. Moreover, longitudinal or mixed-methods studies are recommended to provide a more comprehensive understanding of how differentiated instruction supports students with different cognitive styles over time.

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