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STUDENTS' MATHEMATICAL REPRESENTATION IN SOLVING MATHEMATICAL PROBLEMS THROUGH THE ETHNOMATHEMATICAL CONTEXT OF THE *MBAH MAYANG MADU* TOMB SITE: A COGNITIVE STYLE PERSPECTIVE

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Abstract

Students' mathematical representation processes in ethnomathematics contexts from the perspective of cognitive styles remain underexplored, despite the extensive body of research on mathematical representation. In addition, findings from the preliminary study indicated that many students still experienced difficulties in constructing mathematical representations when solving contextual problems. These conditions highlight the need for further investigation into how students with different cognitive styles develop mathematical representations in ethnomathematics based problem solving contexts. This study aimed to describe the mathematical representation processes of female senior high school students in solving contextual geometry problems based on *Field Independent* (FI) and *Field Dependent* (FD) cognitive styles. This research employed an exploratory descriptive qualitative approach with a case study design. Subjects were selected through a Mathematics Ability Test (AMT) to identify eleventh-grade students with high mathematical ability. From this group, two female students with extreme GEFT scores were then selected as Field Independent (FI) and Field Dependent (FD) subjects. Data were collected through a Problem-Solving Task (PST) based on the local wisdom of the Mbah Mayang Madu Tomb Site in Lamongan and semi-structured interviews, then analyzed using themodel. Data trustworthiness was established through technique and time triangulation. The findings showed that the FI student demonstrated an efficient-symbolic representation process by independently identifying essential information (*disembedding*), internalizing sketches into mental imagery, and directly translating verbal information into symbolic representations. In contrast, the FD student exhibited a narrative-visual representation process by relying on verbal descriptions and external visual sketches to construct mathematical models. These findings indicate that cognitive style influences students' mathematical representation processes and should be considered in designing adaptive geometry learning integrated with local cultural contexts.

Keywords: *Cognitive Style, Ethnomathematics, Mathematical Representation, Problem Solving.*

Abstrak

Proses representasi matematis siswa dalam konteks etnomatematika yang ditinjau dari gaya kognitif masih belum banyak diteliti, meskipun penelitian mengenai representasi matematis telah dilakukan secara luas. Selain itu, hasil studi pendahuluan menunjukkan bahwa banyak siswa masih mengalami kesulitan dalam membangun representasi matematis ketika menyelesaikan masalah kontekstual. Kondisi tersebut menunjukkan perlunya penelitian lebih lanjut mengenai bagaimana siswa dengan gaya kognitif yang berbeda menggunakan representasi matematis dalam konteks pemecahan masalah berbasis etnomatematika. Penelitian ini bertujuan mendeskripsikan profil proses representasi matematis siswi SMA dalam memecahkan masalah geometri kontekstual ditinjau dari gaya kognitif *Field Independent* (FI) dan *Field Dependent* (FD). Penelitian ini menggunakan pendekatan kualitatif deskriptif eksploratif dengan desain studi kasus. Subjek dipilih melalui Tes Kemampuan Matematika (TKM) untuk menjaring siswa kelas XI berkemampuan matematika tinggi, kemudian dari kelompok tersebut dipilih dua siswi dengan skor GEFT ekstrem sebagai subjek Field Independent (FI) dan Field Dependent (FD). Data dikumpulkan melalui Tugas Pemecahan Masalah (TPM) berbasis kearifan lokal Situs Makam Mbah Mayang Madu Lamongan dan wawancara semi terstruktur, kemudian dianalisis menggunakan model Miles et al. (2014). Keabsahan data diperoleh melalui triangulasi teknik dan waktu. Hasil penelitian menunjukkan bahwa siswi FI cenderung menggunakan proses representasi yang efisien simbolik melalui kemampuan memisahkan elemen esensial (*disembedding*), menginternalisasikan sketsa menjadi citra mental,

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dan mentranslasikan informasi secara langsung dari bentuk verbal ke simbolik. Sebaliknya, siswi FD cenderung menunjukkan proses representasi naratif visual dengan memanfaatkan deskripsi verbal dan sketsa visual sebagai jembatan dalam menyusun model matematika. Temuan ini menunjukkan bahwa perbedaan gaya kognitif memengaruhi proses representasi matematis sehingga pembelajaran geometri perlu dirancang secara adaptif dengan memanfaatkan konteks kearifan lokal.

Kata kunci: Etnomatematika, Gaya Kognitif, Pemecahan Masalah, Representasi Matematis.

INTRODUCTION

Mathematics plays a fundamental role in advancing science, technology, and students' analytical thinking skills in the modern era. In Indonesia, this importance has been reinforced through the Regulation of the Head of BSKAP, Ministry of Primary and Secondary Education of the Republic of Indonesia No. 045/H/AN/2025, which identifies mathematical representation as one of the five essential competencies assessed in the Senior High School Academic Competency Test. In line with this policy, mathematical representation is not merely a static supporting tool but a dynamic process involving active mental activities to capture, organize, and express mathematical ideas. According to Zhang & Norman (1994) and Hiebert & Carpenter (1997), a well-structured representation process enables students to transform abstract concepts into more concrete forms, thereby reducing cognitive load when solving complex mathematical problems.

The researchers' preliminary observations further revealed that senior high school students still experience difficulties in solving geometry problems, particularly those related to real life situations. These difficulties are evident in the topics of solid geometry and geometric transformations, especially dilation, where students often experience a sequential failure in the representation process. Difficulties in interpreting initial information lead to errors in constructing symbolic models, which are further exacerbated by inadequate spatial visualization on the coordinate plane. According to Mainali (2021), Agriyanto et al. (2021), and Lam ng et al. (2020), this phenomenon indicates that conventional geometry instruction, which tends to emphasize procedural and abstract approaches, has not sufficiently facilitated students' mathematical representation processes. Therefore, a more contextual learning stimulus closely related to students' real-life experiences is required.

To address these difficulties, according to Aprinastuti and Kovács (2025), an ethnomathematics approach based on local wisdom provides a strategic alternative for creating authentic and meaningful geometry learning experiences. One example of local wisdom rich in geometric concepts in Lamongan Regency is the architecture of the Mbah

Mayang Madu Tomb Site located in Banjarwati Village. Originating from the 16th-century Islamic propagation era in Java, this cultural heritage site possesses profound historical and architectural significance. From the perspective of geometric transformation (Bastianti & Aini, 2025), the four tier octagonal roof illustrates the concept of dilation through its proportionally decreasing roof layers toward the apex. In terms of solid geometry, the architectural structure combines octagonal prisms and pyramids, where each layer reduces systematically at a constant ratio to form a complex three-dimensional aesthetic.

In investigating students' mathematical representation within this ethnomathematics context, it is important to clarify a common misconception that representation is often evaluated solely based on its final product. This study adopts the three standards of mathematical representation proposed by the NCTM (2000), namely creating and using representations to organize, record, and communicate mathematical ideas; selecting, applying, and translating among representations; and using representations to model and interpret phenomena. According to Goldin (2003), these representation processes produce external forms of representation, including verbal, visual, and symbolic representations. Therefore, students' mathematical performance is examined not only through the final representation products but also through the cognitive processes underlying their construction.

According to Ulya & Rahayu (2020), the dynamics of mathematical representation involving various representation products are strongly influenced by students' cognitive characteristics, commonly referred to as cognitive styles. According to Witkin et al. (1977), the dimensions of *Field Independent* (FI) and *Field Dependent* (FD) cognitive styles describe individuals' distinctive ways of processing information and responding to visual stimuli. Students with an FI cognitive style tend to demonstrate strong analytical abilities, separate essential information from its context, and rely on internal cognitive structures. Conversely, students with an FD cognitive style tend to process information holistically, perceive problems as integrated wholes, and depend more heavily on external references or environmental cues. These contrasting cognitive characteristics are expected to produce different patterns of creating, translating, and modeling mathematical representations.

Current literature on mathematical representation and ethnomathematics continues to reveal several important research gaps. Previous studies conducted by Wulandari & Ishartono

(2022) and Pangasta et al. (2024) investigated geometric representations but focused primarily on identifying representation products without examining the underlying translation processes. Meanwhile, Rofi'i et al. (2023) analyzed the influence of *Field Independent* and *Field Dependent* cognitive styles in algebra and trigonometry without considering contextual geometry. Arianto et al. (2026) and Nurfadilah et al. (2026) Both studies similarly employ field independent (FI) and field dependent (FD) cognitive styles as the reviewing variable to examine students' thinking processes in mathematical problem solving. Furthermore, while gender differences in cognitive processing are widely acknowledged, focusing specifically on female students provides crucial theoretical justification. Prior studies (e.g., Adiastuty et al., 2022; Pangasta et al., 2024) highlight that female students typically demonstrate higher verbal-narrative communication preferences but often experience distinct cognitive friction during visual-spatial transformations in geometry. By exclusively selecting female participants, this study controls for gender based spatial reasoning variations, thereby isolating how Field Independent and Field Dependent cognitive styles explicitly drive mathematical representation processes. To the best of the researchers' knowledge, no previous study has comprehensively described the representation process, including creating, translating, and modeling representations encompassing verbal, visual, and symbolic forms among female students with FI and FD cognitive styles within the context of a local cultural heritage site.

The novelty of this study lies in integrating the representation process standards proposed by the National Council of Teachers of Mathematics with Goldin's representation products across each stage of Polya's problem-solving framework from the perspective of female students' cognitive styles within the context of the Mbah Mayang Madu Tomb Site. Based on this background, this study aims to describe in depth the mathematical representation processes, including creating, translating, and modeling representations involving verbal, visual, and symbolic forms, of female senior high school students with *Field Independent* cognitive styles at each stage of Polya's problem-solving process. In addition, this study aims to describe the mathematical representation processes of female senior high school students with *Field Dependent* cognitive styles within the same local cultural context.

METHODS

This study employed an exploratory descriptive qualitative approach with a case study design to examine the mathematical representation processes of eleventh-grade female students with high mathematical ability in solving geometry problems within the ethnomathematical context of the Mbah Mayang Madu Tomb Site in Lamongan. The researcher served as the primary research instrument in participant selection, data collection, analysis, and interpretation.

The study was conducted at SMA Negeri 1 Lamongan during the second semester of the 2025/2026 academic year. Participants were selected through criterion-based purposive sampling, including female students who had learned geometric transformations and solid geometry, ranked in the top 20% of the Mathematics Ability Test (MAT), demonstrated an extreme *Field Independent* (FI) or *Field Dependent* (FD) cognitive style based on the Group Embedded Figures Test (GEFT), showed good communication skills, and voluntarily agreed to participate. Two participants met these criteria: ANZ (FD; GEFT < 12) and SRD (FI; GEFT ≥ 12). The deliberate inclusion of only high achieving students served as a methodological control to ensure that observed representational difficulties and pathways stemmed directly from cognitive style differences rather than foundational mathematical errors or basic conceptual deficits. While selecting two extreme cases limits the statistical generalizability of the findings, it enhances the analytical depth necessary to provide rich, context bound theoretical insights regarding cognitive style driven representation processes.

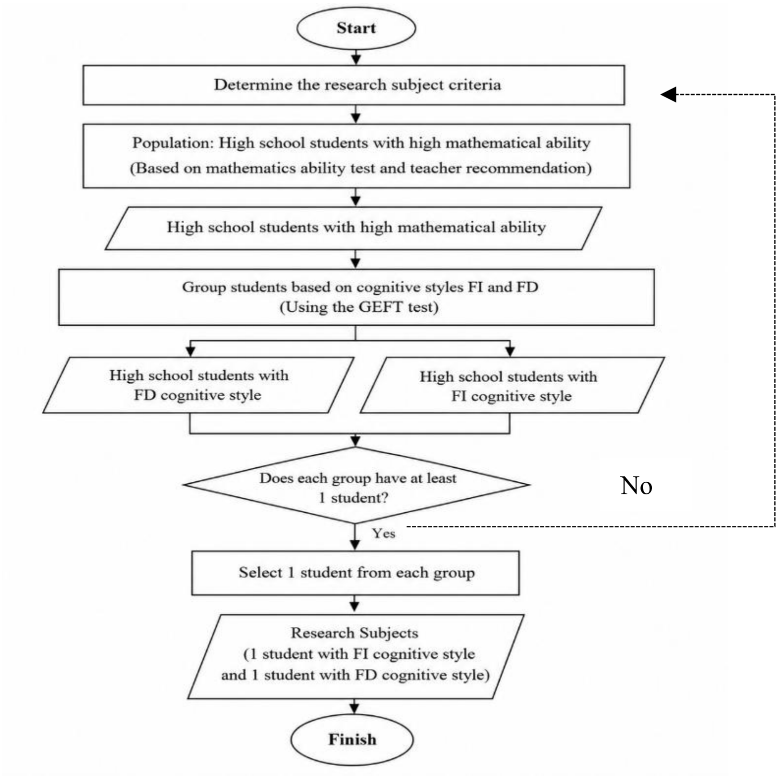

Figure 1. Flowchart of the Research Subject Selection Procedure

Figure 1 illustrates the procedure for determining the research subjects, starting from establishing the class criteria, grouping students based on their FI and FD cognitive styles through the GEFT test, to selecting one student from each group as the research subject, provided that each group has at least one member. The auxiliary instruments included the Mathematics Ability Test (MAT), the Problem-Solving Task (PST) based on the Mbah Mayang Madu Tomb Site, the standardized Group Embedded Figures Test (GEFT) developed by Witkin et al. (1977), and a semi-structured interview guide. The MAT consisted of five essay items assessing conceptual understanding, solution procedures, and final answers. The PST comprised two equivalent task packages (PST-1 and PST-2) designed to elicit the three mathematical representation processes (creating, translating, and modeling) across Polya's four problem-solving stages using the octagonal dome architecture of the tomb site. All instruments were validated by mathematics education experts and experienced teachers, revised based on their feedback, and confirmed as valid and appropriate for use. Readability testing was also conducted with non-participant students to ensure clarity and comprehensibility of the instruments. Table 1 presents the coding matrix of mathematical representation indicators across each of Polya's problem-solving stages, linked to the representation processes defined by NCTM, along with the corresponding code for each indicator.

Table 1.
Coding Matrix of Mathematical Representation Process Indicators within Polya's Problem-Solving Stages

Problem-Solving Stage (Polya 1973)	Representation Process (NCTM)	Indicator	Code
Understanding the Problem	Creating & using representations	Transposing the known and asked elements into drawings, symbols, or one's own sentences as an initial form of understanding the problem.	MM-1
	Selecting & translating between representations	Weighing several possible forms of representation and then translating the problem narrative into pictures/tables or mathematical expressions that best facilitate understanding.	MM-2
	Using representations to model phenomena	Associating the real-world context or phenomenon in the problem with relevant initial mathematical representations to model it.	MM-3
Devising a Plan	Creating & using representations	Designing flowcharts, mathematical models, or sentence descriptions as a strategy map before calculations are performed.	MR-1
	Selecting & translating between representations	Transforming sketches or problem conditions into mathematical expressions (or vice versa) to structure systematic solution steps.	MR-2
	Using representations to model phenomena	Formulating the most appropriate initial mathematical model to describe the phenomenon to be solved.	MR-3
Carrying Out the Plan	Creating & using representations	Actively utilizing the created drawings, diagrams, or equations throughout the calculation process until the answer is obtained.	MP-1
	Selecting & translating between representations	Shifting between forms of representation (visual, symbolic, verbal) as required by the computational stage being executed.	MP-2
	Using representations to model phenomena	Executing the mathematical model of the real phenomenon step by step to produce the final solution.	MP-3
Looking Back	Creating & using representations	Creating comparative representations or re-testing initial representations to ensure the answers and conclusions are correct.	MK-1
	Selecting & translating between representations	Reverting the representation results back to the original problem context to verify their accuracy, and presenting them in the most communicative form.	MK-2
	Using representations to model phenomena	Interpreting the results of mathematical representations into real situations and evaluating the	MK-3

Problem-Solving Stage (Polya 1973)	Representation Process (NCTM)	Indicator	Code
		suitability of the model with the intended phenomenon.	

Data were collected through written Problem-Solving Tasks (PST) and semi-structured interviews. After completing PST-1, each subject participated in an audio, video recorded clarification interview to explore verbal explanations not captured in the written responses. This combination enabled a comprehensive analysis of students' mathematical representation processes and cognitive characteristics (Adiastuty et al. (2022); Anwar et al. (2025)). To ensure trustworthiness, technique and time triangulation were applied by administering PST-2 and a second clarification interview seven days later. Data credibility was established by comparing the consistency of representation process trajectories and cognitive reasoning across both data collections. Furthermore, to minimize researcher bias during coding and qualitative interpretation, strict analytical protocols were enforced. Coding was conducted independently using a standardized analytical rubric derived from NCTM and Polya frameworks, followed by peer debriefing sessions with two senior researchers in mathematics education to verify code consistency. Member checking was also performed by returning interview transcripts and analytical summaries to the participants to confirm that the interpretations accurately represented their cognitive intentions.

Data were analyzed using the interactive model of Miles et al. (2014) comprising data collection, condensation, display, and conclusion drawing. Interview transcripts were coded, reduced, and organized according to cognitive style and test sequence, then categorized based on Polya's problem-solving stages and the three mathematical representation process indicators proposed by NCTM. The findings were presented as descriptive narratives, interview excerpts, and written work samples, and interpreted by comparing the mathematical representation processes of FI and FD students within an ethnomathematical context (Agriyanto et al. (2021); Aprinastuti & Kovács (2025).

RESULTS AND DISCUSSION

RESULTS

1. Profile of the Mathematical Representation Process of the Field Independent Subject (FI - SRD)

a. Understanding the Problem Stage

Regarding the indicator of creating and using representations (MM-1), the FI subject (SRD) initiated the process by utilizing a verbal representation product, which involved carefully reading the problem text and underlining essential numerical information. The subject directly created a symbolic representation product by writing down the known data using standard mathematical notation, such as assigning the symbol s for the length of the base side and t for the distance between the dome levels. The subject consciously eliminated written external visual representation products on the answer sheet because they were deemed inefficient and confusing. This was revealed through the following interview excerpt:

PSI1U-04	:	*Why was it not drawn?*
JSI1U-04	:	*I don't like it. Besides, I am afraid of getting a headache from looking at the pictures. I don't really like it when math problems have pictures; I prefer those that just explain. However, in my head, I can already visualize it, separating it first, and then writing it down.*

Regarding the indicator of translation between representations (MM-2), the FI subject translated the problem directly from its verbal narrative into formal symbolic representations without producing an external visual sketch. Instead, the visualization process was internalized, with the geometric structure of the tomb dome represented as a mental image. This internal spatial disembedding enabled the subject to bypass intermediate external visual sketching and proceed directly to symbolic modeling. This internal representation enabled the subject to model and interpret the real world phenomenon (MM-3) by quickly identifying the multi layered dome as a regular octagonal pyramid, which was mentally decomposed into eight congruent triangles to determine its lateral surface area.

b. Devising a Plan Stage

Regarding the indicator of creating and using representations (MR-1), the FI subject primarily employed symbolic representations to design the solution strategy by constructing a sequence of mathematical formulas, including the distance from the center to the side, the

Pythagorean Theorem, and the paint requirement ratio. Regarding the indicator of translation between representations (MR-2), the subject consistently transformed internal spatial visualization into symbolic mathematical expressions. She also demonstrated the ability to evaluate and revise her representation strategy by replacing the perimeter formula with the lateral surface area formula of a pyramid in PST-2.

Regarding the indicator of modeling and interpreting phenomena (MR-3), the FI subject developed a mathematical model based on logical reasoning about the dome roof structure. She identified the ratio between the image dimensions and the actual dimensions as the most appropriate representation for constructing a scale model.

c. Carrying Out the Plan Stage

Regarding the indicator of creating and using representations (MP-1), the FI subject operated the previously designed symbolic representation as the primary reference during the computational process without the need to re-read the entire problem narrative.

Regarding the indicator of translation between representations (MP-2), the subject's translation pathway followed a flexible pattern (symbolic → verbal → symbolic), occasionally referring back to the problem statement to verify variable values. Although the subject generally relied on symbolic representations throughout the solution process, a visual representation in the form of a concentric layered octagonal drawing was produced only at the end of the task in response to the instruction in Question 2(c), rather than as a cognitive tool during problem solving. Figure 2 illustrates the final octagonal drawing produced by the FI subject, showing four concentric octagonal layers with proportional dimensions that represent the roof structure of the Mbah Mayang Madu Tomb Site. This drawing served as the final visual product of the representation process rather than as an aid for computation.

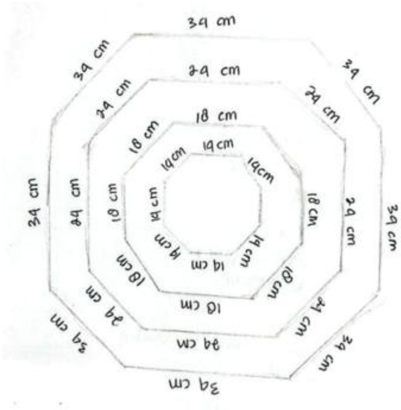

Figure 2. The Result of the Subject FI's Concentric Layered Octagonal Drawing at the End of Carrying Out the Plan Stage for Question 2

Regarding the indicator of modeling and interpreting phenomena (MP-3), the FI subject interpreted the symbolic solution in relation to the real-world context. In estimating the paint requirement, the subject rounded the calculated result upward (from 8.64 to 9 cans) based on the practical consideration that having leftover paint is preferable to running short during the painting process.

d. Looking Back Stage

Regarding the indicator of creating and using representations (MK-1), the subject produced minimal variation in performance. On PST 1, the subject created a new symbolic representation in the form of a written verification proof using the base perimeter approach to verify the accuracy of the answer. Regarding the indicators of translation between representations (MK-2) and modeling and interpreting phenomena (MK-3), the subject's cognitive activity remained entirely within a single register of representation without any new contextual modeling, where the subject regarded the consistency of numerical values when the operation was reversed as the absolute indicator of correctness.

2. Profile of the Mathematical Representation Process of the Field Dependent Subject (FD - ANZ)

a. Understanding the Problem Stage

Regarding the indicator of creating and using representations (MM-1), the FD subject (ANZ) consistently relied on written verbal representation products as the primary basis of understanding by copying down the problem information in a lengthy and literal manner. In addition, to deconstruct visual distractions, the FD subject actively created an independent visual representation product in the form of a small layered octagonal sketch on the margin of the answer sheet, as clarified through the following interview excerpt:

PSD1U-05	:	*I see there are small drawings here as well. Why is that drawing there?*
JSD1U-05	:	*It is just to help me understand, miss. This is the first level, second, third, and fourth. It's redrawn so I can visualize the layers. But it's just a quick sketch to help me understand*

As shown in Figure 3, the FD subject spontaneously produced two simple octagonal sketches to visualize the layered roof structure before beginning the formal solution. These sketches functioned as an external cognitive aid that helped the subject organize spatial information and understand the geometric relationships embedded in the contextual problem rather than serving as the final mathematical representation**.** This spontaneous external visual generation served as an indispensable cognitive bridge to disentangle complex contextual information.

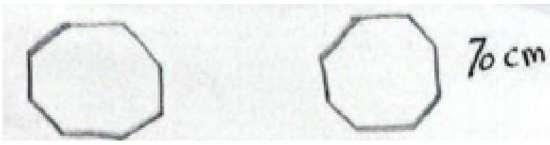

Figure 3. The Spontaneous External Visual Representation (Sketch) Product of the Subject FD at the Understanding the Problem Stage for Question 1

Regarding the indicator of translation between representations (MM-2), the FD subject exhibited a cyclic translation pathway, moving from the verbal representation (reading the problem) to an external visual representation (drawing a small sketch), and then back to a concise written verbal representation in the "known" section. Regarding the indicator of modeling and interpreting phenomena (MM-3), the FD subject linked the real-world context of the problem in an intuitive manner, assuming that the mathematical model was appropriate because it preserved the numerical information provided in the problem statement.

b. Devising a Plan Stage

Regarding the indicator of creating and using representations (MR-1), the FD subject relied exclusively on written verbal representations to devise the solution strategy, expressing geometric formulas in lengthy sentences rather than standard symbolic notation. Regarding the indicator of translation between representations (MR-2), no representational translation was observed because the subject consistently preferred complete verbal formulas over mathematical symbols. As shown in Figure 4, the formulas were written entirely in verbal form, reflecting the subject's reliance on verbal explanations as the primary strategy for organizing mathematical ideas during the planning stage. This heavy reliance on extended verbal descriptions highlights the subject's preference for contextualized cues over abstract mathematical symbols

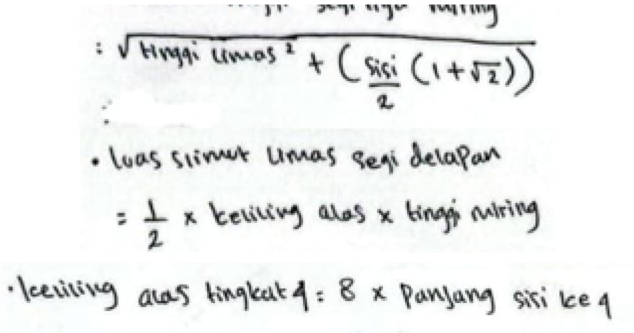

Figure 4. The Written Lengthy Verbal Representation Product for Formulas of the Subject FD at the Devising a Plan Stage for Question 1

Regarding the indicator of modeling and interpreting phenomena (MR-3), the process of modeling and interpreting phenomena did not sufficiently emerge at this stage. The mathematical model developed by the FD subject remained rigid, context-specific, and was closely tied to the information presented in the problem statement.

c. Carrying Out the Plan Stage

Regarding the indicator of creating and using representations (MP-1), the FD subject utilized the lengthy written verbal representation product of the formulas from the previous stage as an initial reference, and then gradually created written symbolic representations when inserting the operational numbers. This transition reveals that the subject required verbal representation as an external anchor to reduce cognitive load before engaging in formal numeric operations. Regarding the indicator of translation between representations (MP-2), the translation pathway moved predominantly from verbal to symbolic forms, accompanied by back-tracking activities (re-reading the "known" statement) whenever the subject experienced cognitive hesitation. This frequent back tracking underscores the subject's ongoing reliance on external stimulus cues whenever working memory capacity was strained during multi-step calculations.

Regarding the indicator of modeling and interpreting phenomena (MP-3), the FD subject was capable of demonstrating the ability to interpret phenomena in a reactive-contextual manner once the symbolic calculation results were obtained, such as rounding the calculated paint requirement upward to 9 cans to anticipate painting failure caused by running short of paint in the real world. This demonstrates that while FD subjects struggle with autonomous abstract modeling, they retain strong practical intuition when evaluating mathematical outcomes against realistic constraints

d. Looking Back Stage

Regarding the indicators of creating and using representations (MK-1), translation between representations (MK-2), and modeling and interpreting phenomena (MK-3), the entire mathematical representation process during the looking back stage was completely eliminated across both task instruments. The subject explicitly stated a refusal to double check because she already felt confident based on her procedural memory of the work and was concerned that finding a different result might instead trigger new cognitive confusion. This complete elimination of representation processes illustrates the premature closure phenomenon, where FD learners prioritize cognitive harmony and procedural confidence over systematic verification.

3. Synchronization of Research Findings Triangulation

To facilitate comparison between the mathematical representation processes of students with *Field Independent* (FI) and *Field Dependent* (FD) cognitive styles, the triangulation findings are summarized in Table 2. The table presents the distinctive characteristics of both subjects across Polya's problem-solving stages and the three mathematical representation process indicators proposed by NCTM (2000).

Table 2. The Matrix of Triangulation Findings on the Mathematical Representation Process of FI and FD Subjects

Problem-Solving Stages (Polya, 1973)	**Comparison of Mathematical Representation Process Indicators (NCTM, 2000)**	**Characteristic Tendencies of the Field Independent Subject (FI - SRD)**	**Characteristic Tendencies of the Field Dependent Subject (FD - ANZ)**
Understanding the Problem	Creating & using representations	Symbolic efficiency; purely utilizing short notations (s and t).	Verbal narrative; copying down the "known" sentences in a lengthy and literal manner.

	Selecting & translating between representations	Unidirectional: Verbal → Symbolic (written visual is absent).	Cyclic: Verbal → External Visual (Sketch) → Verbal.
	Using representations to model phenomena	Spatial deconstruction of the octagonal pyramid directly into a formal mathematical framework.	Linking real-world phenomena in an intuitive-superficial manner.
Devising a Plan	Creating & using representations	Formal symbolic as a thinking tool to construct the strategic roadmap.	Descriptive verbal; writing lengthy sentences for mathematical formulas.
	Selecting & translating between representations	Capable of dynamically revising symbolic representations (*cognitive restructuring*).	Static within the purely verbal register; refusing to translate into formal symbolic forms.
	Using representations to model phenomena	The model is flexible and generalizable.	The model is rigid and non-generalizable (entirely bound to the specific stimulus of the problem sheet).
Carrying Out the Plan	Creating & using representations	Symbolic as a fixed reference; computation moves mechanically from number to number.	Utilizing written verbal representation as an initial anchor before calculating.
	Selecting & translating between representations	Pure visual drawings are produced reactively due to the problem instructions.	Conducting back-tracking activities to the problem's verbal statements when in doubt.
	Using representations to model phenomena	Interpreting the feasibility of calculated results in a purely critical-deductive manner.	Interpreting results in a reactive-contextual manner with real-world reality.
Looking Back	Creating & using representations	Minimal symbolic/verbal-oral purely to verify the consistency of values	The stage is completely skipped due to premature closure.
	Selecting & translating between representations	No cross-register translation occurs post-checking.	The entire set of representation process indicators cannot be identified.
	Using representations to model phenomena	Focused on the aspect of procedural-numerical proof.	Orientation is based on pure procedural confidence.

DISCUSSION

The integration of the mathematical representation process standards proposed by the NCTM (2000), Goldin (2003) classification of representation products, Polya (1973) problem-solving stages, and Witkin et al. (1977) cognitive style theory revealed clear differences in the mathematical representation pathways of female students with *Field Independent* (FI) and *Field Dependent* (FD) cognitive styles when solving geometry problems based on the local wisdom of the Mbah Mayang Madu Tomb Site.

1. Mathematical Representation Process of Female Students with Field Independent (FI) Characteristics

Based on the triangulation findings, the FI student (SRD) demonstrated a representation process characterized by structural independence and efficient symbolic representations throughout Polya's problem-solving stages. During the understanding the problem and devising a plan stages, the subject showed strong disembedding ability by separating essential information from the ethnomathematical context and directly transforming it into symbolic representations without relying on lengthy verbal explanations (Witkin et al., 1977).

These findings are consistent with previous studies showing that FI students process mathematical information analytically and construct solution strategies independently. Arianto et al. (2026) reported that FI students demonstrated stronger mathematical reasoning, while Nurfadilah et al. (2026) found better metacognitive regulation through continuous monitoring and evaluation. The present study extends these findings by showing that these analytical characteristics also shape the construction and transformation of mathematical representations.

A notable finding was the internalization of visual representations. The FI subject deliberately avoided producing external sketches because drawing was considered cognitively distracting. In line with Goldin (2003) and Duval (2006), the octagonal pyramid was represented as an internal mental image that directly guided symbolic construction. This finding also supports Vergnaud (1998), who viewed mathematical representations as dynamic cognitive systems rather than merely observable external products.

The FI subject also demonstrated adaptive cognitive restructuring by revising the initial solution strategy from the perimeter formula to the pyramid's lateral surface area formula. This finding supports NCTM (2000), which emphasizes representations as flexible cognitive tools, and Van Merriënboer (2013), who highlighted the importance of continuously adapting solution strategies during problem solving.

During the carrying out the plan stage, the FI subject consistently relied on symbolic representations. Although a visual representation was eventually produced (Figure 2), it merely fulfilled the task requirement rather than functioning as a computational aid. The subject also interpreted the solution deductively by rounding the paint requirement upward to ensure practical feasibility.

2. Mathematical Representation Process of Female Students with Field Dependent (FD) Characteristics

In contrast, the FD student (ANZ) demonstrated a representation process characterized by reliance on external references and verbal representations. According to Witkin et al. (1977), FD individuals process information holistically and depend on contextual cues. This explains why the subject consistently used lengthy verbal descriptions instead of symbolic notation during the initial stages of problem solving.

These findings agree with previous studies showing that FD students rely more heavily on contextual information. Arianto et al. (2026) found that FD students depended on external information in mathematical reasoning, whereas Nurfadilah et al. (2026) reported greater reliance on external support during metacognitive regulation. The present study extends these findings by demonstrating that this dependence also shapes the sequence of mathematical representation through repeated verbal descriptions and external visual sketches.

The FD subject's dependence on external visuals resulted in a cyclic translation pathway. Unlike the FI subject, who internalized visual imagery, the FD subject spontaneously produced an external sketch (Figure 3) before constructing formal mathematical representations. The representation process moved from verbal information to an external sketch and then back to verbal representations. This finding supports Villegas et al. (2009), who argued that multiple representations facilitate problem solving through translation across representational forms. In this study, however, the sketch primarily functioned as a cognitive aid rather than as the final mathematical representation.

The limitations of the FD cognitive style became evident during the carrying out the plan stage, where the subject experienced temporary disorientation, including unit conversion and procedural errors, and repeatedly referred back to the problem statement to confirm information. Nevertheless, the subject showed strength in interpreting mathematical results within real world contexts by evaluating the practicality of the obtained solution. This finding is consistent with NCTM (2000) and complements the meta-analysis of Widodo et al. (2025), which highlighted the contribution of visual supports to mathematical problem solving. These results suggest that students with FD characteristics particularly benefit from visually enriched learning environments.

Finally, the FD subject did not adequately perform the looking back stage, terminating the solution process once a satisfactory answer had been obtained. This behavior reflects the premature closure tendency described by Witkin et al. (1977), in which individuals rely on initial confidence rather than systematically verifying their solutions.

3. Integrated Comparison and Conceptual Model of Representation Pathways

A direct comparison shows that FI and FD students follow divergent cognitive routes in ethnomathematical problem solving. FI students follow a Direct-Symbolic Abstraction Route (Contextual Input → Mental Imagery → Symbolic Model → Verification), using spatial disembedding to bypass intermediate sketches. In contrast, FD students follow a Cyclic-Visual Scaffolded Route (Contextual Input → External Sketch → Verbal Model → Symbolic Execution), relying on external visual and verbal aids as cognitive bridges. These findings extend existing representation theories (Goldin, 2003; NCTM, 2000) by demonstrating that cognitive style acts as a dynamic filter determining whether visual imagery functions as an internal shortcut (FI) or an external mediating scaffold (FD).

CONCLUSION

This study demonstrates that cognitive styles produce distinct mathematical representation pathways among female students when solving contextual geometry problems. Specifically, students with a Field Independent (FI) cognitive style follow a Direct-Symbolic Abstraction Route characterized by spatial disembedding, internalized visual imagery, and flexible symbolic restructuring. In contrast, Field Dependent (FD) students navigate a Cyclic-Visual Scaffolded Route, relying on verbal descriptions and external visual sketches as essential cognitive bridges before constructing formal mathematical models. Although FD students tended to omit the looking-back stage due to premature closure, they demonstrated strong practical intuition when interpreting mathematical results within real-world contexts.

These findings highlight the need for adaptive mathematics instruction tailored to students' cognitive characteristics. FI students benefit from open-ended tasks that foster autonomous symbolic reasoning, whereas FD students require visual scaffolding, structured graphic organizers, and explicit prompts during the verification stage to prevent procedural errors. Because this study deliberately focused on high-achieving female students within a single ethnomathematical context (the Mbah Mayang Madu Tomb Site) to isolate cognitive style mechanisms, the findings are not intended for broad statistical generalization. Future studies should involve more diverse student profiles, varied mathematical topics, and interactive digital ethnomathematics tools to further refine these representation pathways.

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