Jurnal Elemen, 12(1), 34-48, January 2026
https:/doi.org/10.29408/jel.v12i1.32267

e- ISSN: 2442 - 4226

Check for updates

Numeracy across field-dependent and field-independent cognitive styles of junior high students in Indonesia

Aloisius Loka Son *, Hendrika Bete, Cecilia Novianti Salsinha

Faculty of Teacher Training and Education, Universitas Timor, Indonesia

* Correspondence: aloisiuslokason@unimor.ac.id

Abstract

This study explores differences in numeracy between junior high school students with Field-Dependent (FD) and Field-Independent (FI) cognitive styles. Using a qualitative descriptive approach, the study was conducted in two junior high schools in Kefamenanu, West Timor, Indonesia. Forty students, evenly distributed across the two schools, participated in the study. Data were collected through numeracy tests and in-depth interviews to examine students' performance across three numeracy components: understanding, application, and reasoning. The findings reveal that students with an FI cognitive style generally demonstrated competence in all three components, although some experienced difficulties in reasoning tasks requiring critical evaluation and formal justification. In contrast, students with an FD cognitive style tended to achieve only the understanding and application components and faced persistent challenges in progressing to the reasoning component. These results highlight the importance of differentiated numeracy instruction. FD students benefit from visual representations, explicit guidance, and collaborative learning to strengthen foundational, whereas FI students require non-routine and argumentative tasks to enhance higher-order reasoning. This study recommends that educators and future researchers implement inclusive numeracy literacy practices aligned with students' cognitive styles.

Keywords: cognitive style; field dependent-independent; numeracy

How to cite: Son, A. L., Bete, H., & Salsinha, C. N. (2026). Numeracy across field-dependent and field-independent cognitive styles of junior high students in Indonesia. *Jurnal Elemen, 12*(1), 34-48. https://doi.org/10.29408/jel.v12i1.32267

Received: 9 September 2025 | Revised: 5 October 2025
Accepted: 30 January 2026 | Published: 19 February 2026

Introduction

Twenty-first-century education requires students to develop higher-order thinking skills, one of which is numeracy. Numeracy is not limited to computational ability but also encompasses the capacity to understand, interpret, and apply mathematical concepts across diverse real-life contexts(OECD, 2023a). Students with strong numeracy competence demonstrate this through their ability to employ concepts, procedures, facts, and mathematical tools to solve everyday problems (Son et al., 2023). At the junior high school level, mastery of numeracy serves as a foundation for the development of more advanced skills required in subsequent levels of education, such as in science, technology, and other fields. Therefore, in the context of Indonesian education, numeracy has become one of the key indicators for measuring student learning outcomes.

Despite continuous efforts to strengthen numeracy, evidence consistently shows that Indonesian students' performance in this domain remains relatively low. The PISA 2022 report indicates that the average mathematics score of Indonesian students is still below the OECD mean, with a considerable proportion of students experiencing difficulties in solving context-based problem-solving tasks (OECD, 2023b). Furthermore, when viewed across the last three PISA cycles, the trend reveals that Indonesian students have yet to demonstrate substantial progress, suggesting persistent challenges in equipping learners with the higher-order thinking required in 21st-century education. This highlights the urgent need for more effective pedagogical approaches and policy interventions to enhance numeracy outcomes.

The mathematics achievement scores of Indonesian students based on the results of the 2015 PISA survey were 386 (OECD, 2016), 379 in 2018 (OECD, 2019), and 366 in 2022 (OECD, 2023b). These results show that Indonesian students' mathematical literacy has not met expected standards, with a downward trend in performance over the past three cycles. Beyond merely describing a decline in scores, the data indicate persistent weaknesses in students' ability to understand, apply, and reason with numerical information when confronted with non-routine, context-based problems, which constitute the core of numeracy within the PISA framework. This pattern suggests that the primary challenge lies not only in learning outcomes but also in students' cognitive processes for processing numerical information and selecting appropriate problem-solving strategies.

Similar challenges are evident among eighth-grade students in junior high schools in Kefamenanu, West Timor, Indonesia. Research by Son et al. (2023) revealed that the more complex the indicators used to assess numeracy, the lower the students' performance; conversely, when the assessment indicators were simpler, students achieved better results. Overall, this study suggests that students' numeracy competence remains below the expected standard. Supporting evidence was also reported by Jelahu et al. (2023), who found that students with low mathematical literacy are only able to demonstrate mastery at the understanding level. However, they have not demonstrated adequate mastery in the application and reasoning aspects.

Numeracy involves not only computation but also logical reasoning, quantitative thinking, and the ability to solve context-based problems. Consequently, the development of numeracy is strongly influenced by cognitive factors, including students' cognitive styles. Cognitive style refers to the way individuals process, store, and use information when responding to tasks or interacting with different environmental situations (Carraher et al., 2017). In relation to students' numeracy, cognitive style plays a crucial role and makes a significant contribution, as it shapes how learners express and apply their mathematical literacy (Rum & Juandi, 2023).

One of the most widely recognized classifications of cognitive styles is field-dependent (FD) and field-independent (FI) (Witkin et al., 1977). These two styles have remained prominent in educational research (Mefoh et al., 2017). FD students tend to rely on external context and guidance from others when processing information, whereas FI students are more independent, analytical, and able to separate information from its surrounding context (Wang & Kao, 2022). In other words, FD learners are context-bound, whereas FI learners are context-free (Karaçam & Baran, 2015).

The influence of FD and FI cognitive styles on numeracy has increasingly gained attention in mathematics education literature. These cognitive styles play an important role in shaping students' mathematical literacy and should be carefully considered in teacher education programs (Santoso & Sari, 2025). Cognitive styles affect how students employ their mathematical literacy (Rum & Juandi, 2023), including in mathematical problem-solving. Therefore, understanding the problem-solving abilities of FI and FD students has become a crucial focus and provides an important basis for contemporary research (Son & Fatimah, 2020, 2021).

A growing body of research has demonstrated that differences in cognitive style can influence how students understand and solve mathematical problems, including in the context of numeracy. For instance, FI students tend to excel in tasks requiring logical and abstract thinking, whereas FD students are generally more comfortable with visual and context-based approaches (Karami & Shahrokhi, 2021).

Although recent studies indicate that field-independent (FI) and field-dependent (FD) cognitive styles play an important role in mathematics learning, most existing research has primarily focused on general cognitive achievement or mathematical problem-solving rather than numeracy, which emphasizes the understanding, application, and reasoning of numerical information in authentic contexts (Engelbrecht et al., 2020; OECD, 2023a). Furthermore, studies integrating cognitive styles and numeracy have predominantly adopted quantitative approaches and rarely explored students' cognitive processes in depth, leaving differences in numerical reasoning strategies between FI and FD students insufficiently explained (Hadi & Csíkos, 2025; Wang & Kao, 2022). This indicates that qualitative studies specifically examining numeracy through the lens of FI and FD cognitive styles at the junior high school level remain highly limited.

Building on this gap, the present study investigates the numeracy of junior high school students in relation to their field-dependent and field-independent cognitive styles. The findings are expected to contribute to the design of more adaptive instructional strategies that account for students' cognitive differences, thereby promoting more effective and equitable improvements in numeracy.

Methods

This study employed a qualitative descriptive design. The qualitative descriptive method emphasizes the observation of phenomena and the exploration of their underlying meanings, focusing on research processes to obtain accurate findings. The study was conducted with eighth-grade students from two public junior high schools (School A and School B) in Kefamenanu, West Timor, Indonesia, during the odd semester of the 2024 academic year. Both schools are located in the center of Kefamenanu City and use the national curriculum. These schools are also often designated as model schools for other schools.

Forty students participated in the study: 20 from School A and 20 from School B. All participants engaged in the full research process, which included a numeracy test, in-depth interviews, and the Group Embedded Figures Test (GEFT). The results of the numeracy test were categorized into three levels: high, medium, and low. Based on the GEFT results, students were further classified as either FI or FD. From this classification, six students were selected to represent different levels of numeracy and FI–FD cognitive styles. These six participants included three from School A and three from School B, each representing different cognitive styles. This interview aimed to confirm the students' written answers; therefore, only six participants were used as interview sources.

The research instruments comprised the GEFT, a numeracy test, and interviews. The GEFT was used to measure students' FI and FD cognitive styles. The test comprised 18 items, with students scoring 0 to 11 categorized as having FD and those scoring 12 to 18 categorized as having FI (Witkin et al., 1977). The numeracy test was designed to assess students' numeracy competence through three tasks, each representing one aspect of numeracy: understanding, application, and reasoning. Before this numeracy test was administered, it was first validated by two mathematics education experts. The evaluation results indicated that the test was valid and appropriate for use. Interviews were employed to strengthen and triangulate the test data. During the interviews, students were asked questions aimed at exploring their numeracy in greater depth. The interview process was guided by a semi-structured protocol and was conducted based on the students' performance in the numeracy test. These tests and structured interviews served as triangulation techniques to maintain credibility in this study. The data were analyzed using a modified version of Miles et al. (2013) qualitative data analysis framework, which follows a cyclical process, as illustrated in Figure 1.

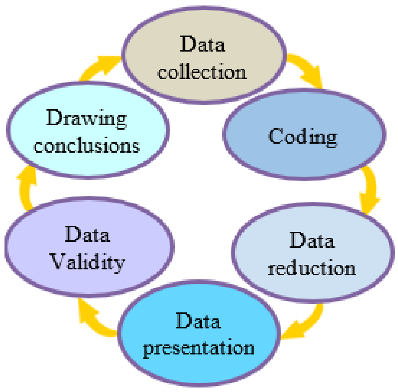

Figure 1. Data analysis

Results

Based on the 40 student participants in this study, the distribution of FI–FD cognitive styles are presented in Table 1.

Table 1. Distribution of students' FI-FD cognitive styles

School	FI	FD	Total
School A	8	12	20
School B	7	13	20
Total	15	25	40

The results of the numeracy test for FI and FD students are detailed in Table 2.

Table 2. Description of students' numeracy

Cognitive style	N	Mean	Std. Deviation
FI	15	71.55	24.75
FD	25	60.13	22.39

Based on the results of the test, six students were selected to represent different levels of numeracy and FI–FD cognitive styles for further interviews. These six students were chosen based on their ability to communicate verbally. The selected participants are presented in Table 3.

Table 3. Interview participants

Initial	Cognitive style	Score
FI_1	FI	93.33
FI_2	FI	76.67
FI_3	FI	60.00
FD_1	FD	76.67
FD_2	FD	50.00
FD_3	FD	20.00

Six students were interviewed to validate their written assignments; however, this article presents only selected excerpts from the worksheets and interview transcripts of two of them. The first student is coded FI_1 (hereafter FI), and the second FD_1 (hereafter FD). Although the written work and interview data from these two students are included as illustrative examples, the findings and conclusions reported in this article are based on a comprehensive analysis of the entire dataset collected for this study.

Numeracy of FI Students

The FI student's solution for the understanding aspect is presented in Figure 2. The FI student's understanding skill was confirmed through an interview conducted by the researcher (R), as illustrated in the following excerpt.

R : *Based on the problem you read, what facts are given in this question?*
FI : *The points A (2, -3) and B (-1, 4).*
R : *What is being asked in the problem?*
FI : *I was asked to draw a line connecting points A and B.*
R : *What steps did you take to draw the line?*
FI : *I plotted points A and B, then connected them to form a line.*

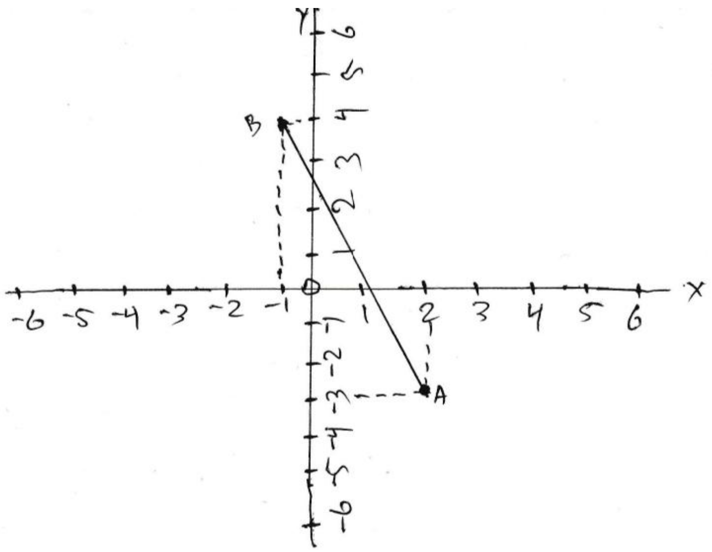

Figure 2. Excerpt of FI student's solution in the understanding aspect

Based on Figure 2 and the student's responses in the interview excerpt above, it can be concluded that the FI student demonstrated the ability to recognize the known and unknown elements of the problem and determine an appropriate strategy for solving it. This was evident in the solve the problem process, where the FI student was able to determine the coordinate points and accurately plot all given points on the Cartesian coordinate system. The student also correctly connected point A (2, –3) and point B (–1, 4) to form line segment AB on the Cartesian plane.

Similarly, in the problem assessing the application aspect, the FI student successfully solved it, can presented in Figure 3.

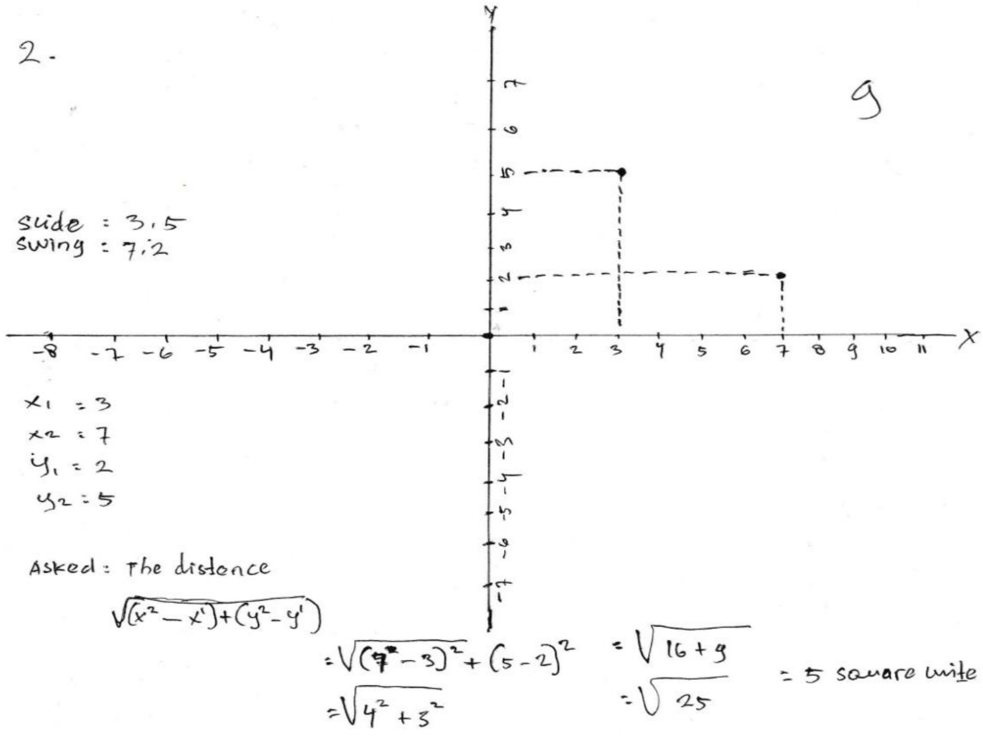

Figure 3. Excerpt of FI student's solution in the application aspect

The working process of the FI student on the application aspect can be confirmed through an interview conducted by the researcher, as illustrated in the following excerpt.

R : *Based on the problem you read, what facts are provided in the question?*
FI : *The coordinates of the slide point are (3,5) and the swing point are (7,2).*
R : *According to you, what is being asked in the problem?*
FI : *I was asked to calculate the distance.*
R : *How did you proceed to calculate the distance?*
FI : *I used the distance formula to determine the distance between the slide point and the swing point.*
R : *After identifying that you would use the distance formula, what did you do next?*
FI : *I performed the calculation and found that the final result of the distance between the two points is 5 units.*

Based on Figure 3 and the student's responses in the interview excerpt above, it can be concluded that the FI student was able to apply mathematical concepts in solving problems related to the application aspect of numeracy.

In this reasoning aspect, the FI student demonstrated the ability to reason using mathematical concepts to solve the problem. The FI student's reasoning-based problem-solving process is presented in Figure 4.

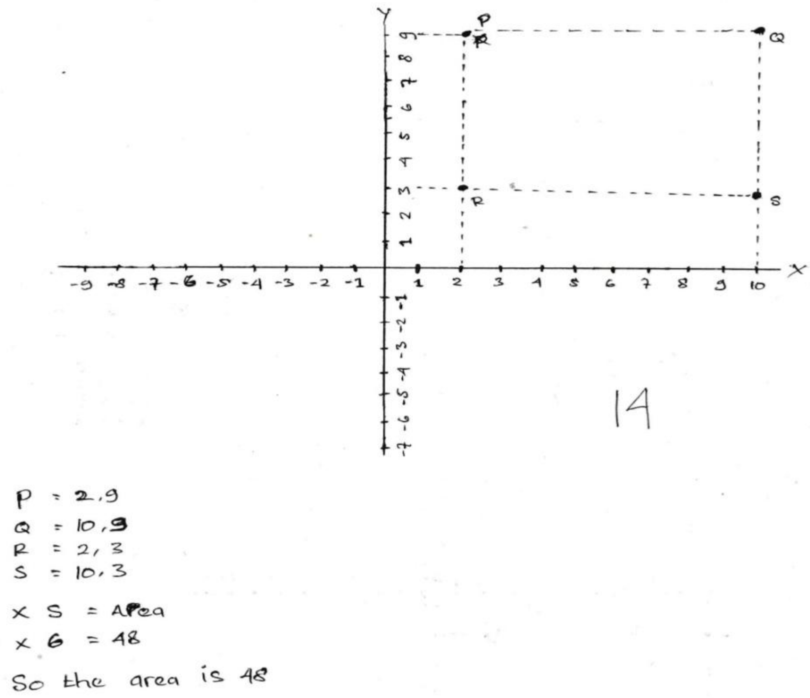

Figure 4. Excerpt of FI student's solution in the reasoning aspect

The following interview excerpt highlights the FI student's reasoning process in solving the problem, as documented by the researcher.

R : *Based on the problem you have just read, what facts are provided in the question?*
FI : *The given coordinate points of the land are P(2,9), Q(10,9) and R(2,3).*
R : *Next, what is being asked in the problem?*
FI : *It asks to calculate the area of a rectangular piece of land.*
R : *How did you determine the area of the land?*

FI : *First, I plotted the given points from the problem.*
R : *In your opinion, can the area of a rectangle be calculated if only three points are provided?*
FI : *No, an additional point is needed.*
R : *How did you add another point?*
FI : *I added one more point, namely S(10,3), to complete the rectangle..*
R : *Then, how did you calculate the area of the land?*
FI : *I calculated the area using the formula for the rectangle, namely length × width.*

Based on Figure 4 and the interview excerpt, initially, the student identified three given coordinate points, namely P (2,9); Q (10,9) and R (2,3). The student understood that calculating the area of a rectangle cannot be accomplished with only three points; therefore, one additional point, S (10,3), was added. The FI student was able to devise a solution to the problem that required reasoning ability. In the calculation process, the student used all four points, plotted them on the Cartesian plane, and then determined the length and width. Subsequently, the student applied the area formula (length × width) to calculate the area of the field.

Numeracy of FD Students

The FD student demonstrated competence in the understanding and application aspects but showed limited reasoning ability. The FD student's problem-solving process for the understanding aspect is illustrated in Figure 5.

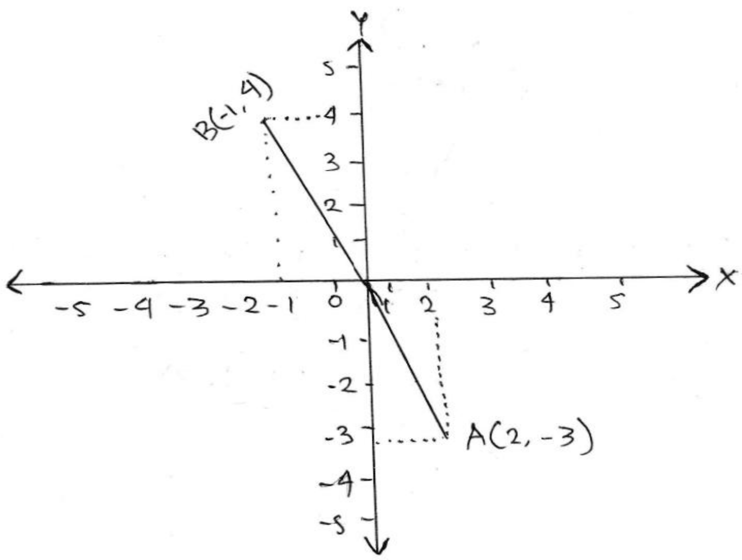

Figure 5. Excerpt of FD student's solution in the understanding aspect

The following interview excerpt highlights the FD student's understanding process in solving the problem, as documented by the researcher.

R : *Based on the problem you read, what facts are given in the question?*
FD : *The points A (2, −3) and B(−1, 4).*
R : *According to you, what is being asked in the problem?*
FD : *I was asked to connect point A and point B with a line.*
R : *What steps did you take to connect point A and point B with a line?*
FD : *I began by drawing the X-axis and Y-ordinate.*

R : *What did you do after drawing the X-axis and Y-ordinate?*
FD : *I plotted point A and point B, then connected the two points to form a line.*

Based on Figure 5 and the interview excerpt with the FD student, it can be concluded that the student was able to identify both the known and required information from the problem and determine an appropriate solution strategy. This was evident as the student correctly identified and plotted the given coordinate points on the Cartesian plane and connected points A(2, −3) and B(−1, 4) to form line segment AB.

Furthermore, in the application aspect, the FD student was also able to solve the problem correctly. The FD student's solution for the application aspect is presented in Figure 6.

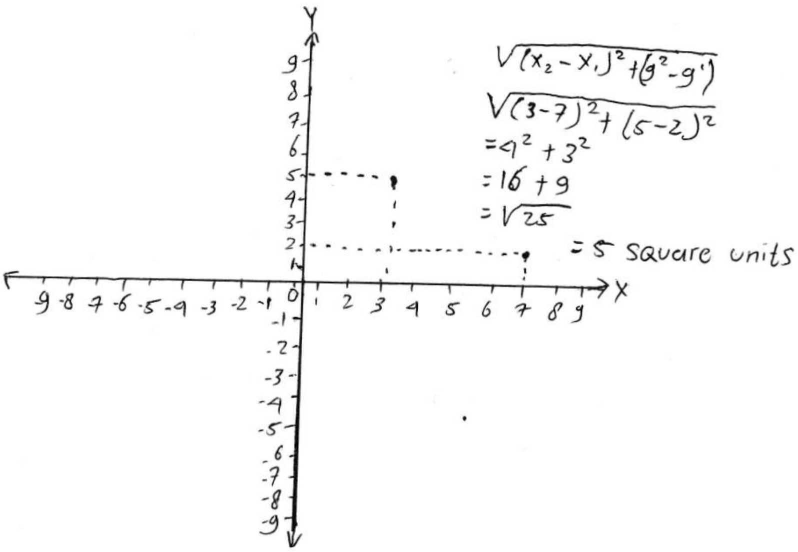

Figure 6. Excerpt of FD student's solution in the application aspect

The following interview excerpt highlights the FD student's application process in solving the problem, as documented by the researcher.

R : *Based on the problem you read, what facts are given in the question?*
FD : *The origin point (0,0), the slide point (3,5), and the swing point (7,2).*
R : *According to you, what is being asked in the problem?*
FD : *The distance between the slide point and the swing point.*
R : *How did you proceed to calculate the distance?*
FD : *I used the distance formula, namely* $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
R : *After identifying that you would use the distance formula, what did you do next?*
FD : *I calculated it as* $(3\text{-}7)^2 + (5\text{-}2)^2 = 4^2 + 3^2 = 16 + 9 = 25$, then took the square root, resulting in a distance of 5 units.

Based on Figure 6 and the interview excerpts above, it can be concluded that the FD student was demonstrated comprehension of the given facts and the problem, although a minor conceptual error occurred when writing (3−7) = 4 instead of (3−7) = −4. However, the final result remained correct because the value was squared.

In solving a problem that measured the aspect of reasoning, the FD student was only able to plot three points on the Cartesian coordinate plane. Nevertheless, the student was unable to determine the remaining point so that when all four points were connected, they would form a rectangle. The FD student's solution to the reasoning problem is presented in Figure 7.

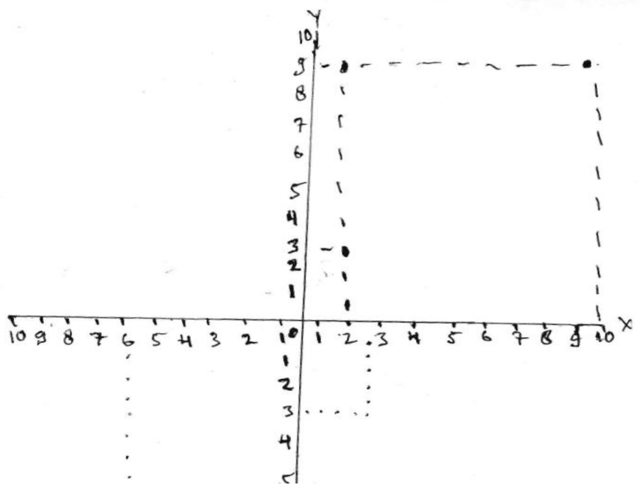

Figure 7. Excerpt of FD student's solution in the reasoning aspect

The following interview excerpt highlights the FD student's reasoning process in solving the problem, as documented by the researcher.

R : *Based on the problem statement, what facts can be identified in the task?*
FD : *The land coordinates are given as P(2,9); Q(10,9) and R(2,3).*
R : *According to you, what issues are being asked in the problem?*
FD : *Determine the area of the land.*
R : *What mathematical concept is used to determine distance?*
FD : *I do not know.*
R : *Are there any other facts found in this problem?*
FD : *I do not know.*
R : *Can you use the known facts and other information to solve this problem?*
FD : *I cannot.*

Based on Figure 7 and the interview excerpts, it can be concluded that in solving the reasoning problem, the FD student was unable to determine the remaining point so that when all four points were connected, they would form a rectangle. As a result, the FD student was only able to plot the three known points on the Cartesian plane. The student was not yet able to demonstrate reasoning skills in addressing a more complex problem. This reasoning task falls into the category of non-routine problems, which the FD student was unable to solve.

The excerpts of student work and interview transcripts presented earlier represent two students, FI and FD, who achieved the highest numeracy scores in this study. Although this article does not present the complete written work or full interview transcripts for FI and FD across all numeracy categories, all relevant data were incorporated into the overall analysis. The analysis shows that student FI in the medium numeracy category was able to complete tasks at the understanding level and demonstrated the ability to apply mathematical concepts at the application level, but was not yet able to solve reasoning-level items. In contrast, the same student, when classified in the low numeracy category, was only able to complete numeracy tasks at the understanding level.

In contrast to students with FI's cognitive style, FD students' highest performance falls within the medium category, where they still exhibit limitations in the reasoning assessment aspect. At this level, FD students have difficulty solving items that measure reasoning. Some students are able to apply mathematical concepts to solve contextual problems from daily life, while others continue to struggle in this aspect. Moreover, FD students in the low category exhibit difficulties even with understanding-level tasks, making items that require application and reasoning substantially more challenging for them.

Discussion

The results of the study indicate that, in general, students with a Field-Independent (FI) cognitive style have achieved understanding, application, and reasoning, although a small number still experience difficulties in the application and reasoning aspects. In contrast, students with a Field-Dependent (FD) cognitive style have not achieved the reasoning aspect; they tend to only achieve understanding and application, and some of them even experience difficulties in the understanding and application aspects. These findings illustrate that reasoning is the core of numeracy and that its attainment requires higher-order thinking skills. The PISA 2022 framework defines numeracy as the ability to understand, apply, and interpret mathematics in a variety of real-world contexts, with reasoning as a central element that demands justification, evaluation, and argumentation (OECD, 2023a). This implies that, to achieve reasoning, students must not only understand and apply concepts but also connect evidence, assess claims, and evaluate solutions. The complexity of reasoning in numeracy thus requires higher-order cognitive processes from both FI and FD students.

FI students possess the ability to disembed, namely, the capacity to separate relevant information from complex contexts. This mechanism enables them to extract essential data, construct mathematical models, and develop logical arguments. Morris et al. (2019) revealed that FI students are better prepared to navigate context-rich mathematical performance tasks (graphs/tables/texts), identify essential quantities, model them, and formulate arguments to support decisions. Nevertheless, the findings also show that some FI students still experience difficulties when reasoning requires critical evaluation or formal justification.

Although FI students possess advantages in disembedding information and conducting analysis, formal reasoning requires additional skills, such as evidence-based justification and critical evaluation of mathematical arguments. According to Lithner (2017), many students tend to employ imitative reasoning (replicating solution patterns) rather than creative reasoning (constructing novel arguments). This may explain why some FI students remain trapped in algorithmic patterns without being able to construct deeper justifications. In other words, disembedding supports them in the initial stages (understanding and application); however, it does not automatically guarantee maturity in mathematical argumentation without explicit practice.

In many instructional practices, greater emphasis is placed on procedural understanding and the application of routine problems rather than justification or mathematical argumentation. As a result, although FI students are often able to solve problems, some are not accustomed to articulating why a solution is valid. Jonsson et al. (2022) emphasize that to foster creative mathematical reasoning, non-routine tasks are required that compel students to explain their thinking processes rather than merely producing a final answer through procedural means.

In contrast to FI students, FD students are more bound to external contexts and tend to process information globally (Karaçam & Baran, 2015). In complex numeracy tasks, this tendency hinders their ability to abstract relevant variables. Recent research has found that cognitive style mediates the relationship between visual perception and mathematical performance; FD students are less effective in extracting quantitative information from visual representations, thereby limiting their achievement to understanding and application (Vecchione et al., 2023).

Moreover, limitations in executive functions, particularly sustained attention and inhibitory control, present additional obstacles for FD students. Cueli et al. (2020) reported that attention and inhibitory control are strongly related to early numerical. This condition explains why some FD students still struggle, even with understanding and application. Such findings call for a deeper analysis, as understanding and application should constitute the foundation before students can progress to the reasoning stage.

Regarding executive functions, Cragg and Gilmore (2014) emphasize that numeracy performance is strongly shaped by the efficiency of core executive components: working memory, inhibition, and shifting. However, this relationship is not entirely direct, as FI–FD cognitive styles can act as mediators through their influence on strategy selection and differential cognitive control demands. FI students tend to process information analytically and can isolate relevant cues from distracting visual elements, allowing them to engage in numeracy tasks with more efficient working memory use and reduced inhibitory load (Wang & Kao, 2022; Witkin et al., 1977). In contrast, FD students are more influenced by surface-level contextual features and often rely on procedural strategies that impose greater working memory demands while requiring stronger inhibition to manage distractions. This mechanism explains why students with similar executive function capacities may nevertheless exhibit different levels of numeracy performance depending on whether they are FI or FD (Cragg & Gilmore, 2014).

Accordingly, the implementation of differentiated instruction that aligns task structures with students' cognitive profiles becomes essential for optimizing the coordination of executive functions in numeracy performance (Cragg & Gilmore, 2014). This approach helps FD students achieve more stable numeracy outcomes and ensures that both FI and FD learners receive equitable opportunities to develop their numeracy.

Conclusion

Students with Field-Independent (FI) cognitive style have achieved understanding, application, and reasoning aspects; although a small proportion still face difficulties in reasoning tasks that demand justification and the evaluation of arguments. FI students are able to navigate complex context-based numeracy problems; however, when confronted with tasks requiring critical evaluation and advanced mathematical argumentation, some FI students continue to experience challenges. In contrast, students with Field-Dependent (FD) cognitive style have not yet reached the reasoning aspect; they tend to remain at the levels of understanding and application, and some of them even continue to struggle with these aspects. FD students demonstrate limitations in decontextualizing information.

It is recommended that middle-school mathematics teachers implement differentiated instruction that aligns numeracy task structures with students' cognitive styles. To support the reasoning aspects of FI students, teachers should consistently provide non-routine, context-rich problems that require justification. In contrast, FD students benefit from clear visual and structural scaffolding, such as highlighting critical information, using focused diagrams, and providing simple argument frameworks (claim–evidence–reasoning). Although tailoring instruction for both FI and FD learners is challenging in large classrooms, teachers are encouraged to adopt these practices to ensure equitable opportunities for the development of numeracy among all students.

This study was conducted with a small and localized sample, which limits the generalizability of the findings. Therefore, future researchers are encouraged to conduct experimental studies employing differentiated instruction tailored to FI-FD cognitive profiles with larger participant groups and to conduct mixed-methods research to examine the role of instructional design and its effects on students' numeracy performance.

Acknowledgment

The authors would like to express their deepest gratitude to the Institute for Research and Community Service (LPPM) of Universitas Timor for their financial support and valuable contributions, which played a crucial role in facilitating this research. LPPM's support played a crucial role in the successful completion of this research.

Declarations

Conflicts of Interest	:	The authors declare no conflict of interest.
Generative AI Statement	:	AI Used for Limited, Non-Substantive Support: Generative AI tools, such as Grammarly were employed solely for language editing and minor phrasing enhancements. All conceptualization, analysis, and scholarly content were independently developed and verified by the authors.
Funding Statement	:	This study was conducted with financial support from the Institute of Research and Community Service of Universitas Timor, whose contribution was crucial in the successful completion of this research [Internal grant 2024 No. 149/UN60.6/PP/2024].
Author Contributions	:	**Aloisius Loka Son:** Conceptualization, Writing - Original Draft, Project administration and Editing; **Hendrika Bete:** Formal analysis and Writing - Review & Editing; **Cecilia Novianti Salsinha:** Methodology and Validation; Writing - Review & Editing.

References

Carraher, E., Smith, R. E., & Lisle, P. (2017). *Cognitive styles: leading collaborative architectural practice*. Jhon Wiley & Sons. https://doi.org/10.1177/002221947000300101

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: the role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education*, *3*(2), 63–68. https://doi.org/10.1016/j.tine.2013.12.001

Cueli, M., Areces, D., García, T., Alves, R. A., & González-Castro, P. (2020). Attention, inhibitory control, and early mathematical Skills in preschool students. *Psicothema*, *32*(2), 236–242. https://doi.org/10.7334/psicothema2019.225

Engelbrecht, J., Borba, M. C., Llinares, S., & Kaiser, G. (2020). Will 2020 be remembered as the year in which education was changed? *ZDM–Mathematics Education*, *52*(5), 821–824. https://doi.org/10.1007/s11858-020-01185-3

Hadi, W., & Csíkos, C. (2025). A systematic review on visualization in mathematical problem-solving in secondary schools. *European Journal of Science and Mathematics Education*, *13*(4), 352–367. https://doi.org/10.30935/scimath/17410

Jelahu, R. A., Son, A. L., Bete, H., García-García, J., Sudirman, S., & Alghadari, F. (2023). Profile of middle school students' mathematical literacy ability in solving number pattern problems. *International Journal of Science Education and Cultural Studies*, *2*(1), 1–14. https://doi.org/10.58291/ijsecs.v2i1.72

Jonsson, B., Norqvist, M., Liljekvist, Y., & Lithner, J. (2022). Creative mathematical reasoning: does need for cognition and working memory capacity predict benefits from con-routine Practice? *Frontiers in Psychology*, *13*, 859673. https://doi.org/10.3389/fpsyg.2021.797807

Karaçam, S., & Baran, A. D. (2015). The effects of field dependent/field independent cognitive styles and motivational styles on students' conceptual understanding about direct current circuits. *Asia-Pacific Forum on Science Learning and Teaching*, *16*(2), 1–19. https://eric.ed.gov/?id=EJ1096071

Karami, H., & Shahrokhi, M. (2021). The relationship between cognitive styles and mathematical problem solving among high school students. *Journal of Educational Psychology*, *113*(3), 458–472.

Lithner, J. (2017). Principles for designing mathematical tasks that enhance imitative and creative reasoning. *ZDM Mathematics Education*, *49*(6), 937–949. https://doi.org/10.1007/s11858-017-0867-3

Mefoh, P. C., Nwoke, M. B., & Chijioke, J. B. C. C. A. O. (2017). Effect of cognitive style and gender on adolescents' problem solving ability. *Journal of Thinking Skills and Creativity*, *25*, 47–52. https://doi.org/10.1016/j.tsc.2017.03.002

Miles, M. B., Huberman, A. M., & Saldana, J. (2013). *Qualitative data analysis: a methods sourcebook*. SAGE Publications, Thousand Oaks. https://books.google.co.id/books?id=p0wXBAAAQBAJ&printsec=frontcover&hl=id#v=onepage&q&f=false

Morris, S., Farran, E. K., & Dumontheil, I. (2019). Field independence associates with mathematics and science performance in 5-10 year-olds after accounting for domain-general factors. *Mind, Brain, and Education*, *13*(3), 167–177. https://doi.org/10.1111/mbe.12214

OECD. (2016). *PISA 2015 Results in Focus*. OECD Publishing. https://doi.org/10.1787/aa9237e6-en

OECD. (2019). *PISA 2018 Results: What Students Know and Can Do*. OECD Publishing. https://doi.org/10.1787/5f07c754-en

OECD. (2023a). *PISA 2022 Assessment and analytical framework*. OECD Publishing. https://doi.org/10.1787/dfe0bf9c-en
OECD. (2023b). *PISA 2022 Results (volume I): student performance*. OECD Publishing. https://doi.org/10.1787/19963777
Rum, A. M., & Juandi, D. (2023). Students mathematical literacy viewed from cognitive style: systematic literature review. *Jambura Journal of Mathematics Education*, *4*(1), 1–10. https://doi.org/10.34312/jmathedu.v4i1.17438
Santoso, F. G. I., & Sari, A. E. R. M. (2025). Mathematical literacy of prospective mathematics teacher based on cognitive style. *Jurnal Elemen*, *11*(2), 427–446. https://doi.org/10.29408/jel.v11i2.28494
Son, A. L., & Fatimah, S. (2020). Students' mathematical problem-solving ability based on teaching models intervention and cognitive style. *Journal on Mathematics Education*, *11*(2), 209–222. https://doi.org/10.22342/jme.11.2.10744.209-222
Son, A. L., & Fatimah, S. (2021). The position of students' errors in algebraic problem-solving based on field dependent and independent. *Kalamatika: Jurnal Pendidikan Matematika*, *6*(1), 57–70. https://doi.org/10.22236/KALAMATIKA.vol6no1.2021pp57-70
Son, A. L., Talan, M. R., Mone, F., & Jelahu, R. A. (2023). Profil kemampuan literasi dan numerasi siswa sekolah menengah pertama [Profile of literacy and numeracy ability of junior high school students. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 922–932. https://doi.org/10.24127/ajpm.v12i1.6569
Vecchione, F., Giancola, M., Palmiero, M., Marucci, F. S., Piccardi, L., & D'Amico, A. (2023). Field dependence-independence mediates the association between visual perception and mathematics: a cross-sectional study in children and preadolescents. *European Journal of Developmental Psychology*, *20*(6), 888–905. https://doi.org/10.1080/17405629.2023.2177726
Wang, T. H., & Kao, C. H. (2022). Investigating factors affecting student academic achievement in mathematics and science: cognitive style, self-regulated learning and working memory. *Instructional Science*, *50*(5), 789–806. https://doi.org/10.1007/s11251-022-09594-5
Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research*, *47*(1), 1–64. https://doi.org/10.3102/00346543047001001