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COGNITIVE PATTERNS AND UNDERSTANDING OF MATHEMATICAL CONCEPTS IN INTEGRATED PROBLEM-BASED LEARNING OF AMBON CULTURE

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Abstrak

Penelitian ini bertujuan untuk menganalisis pola kognitif dan pemahaman konsep matematika siswa dalam pembelajaran berbasis masalah yang terintegrasi etnomatematika pada materi perbandingan. Penelitian ini menggunakan *mixed method* dengan data kuantitatif berupa skor pemahaman konsep dan data kualitatif berupa jaringan kode serta peta konsep yang merepresentasikan hubungan antara proses pembelajaran, konteks budaya Ambon, dan respon afektif siswa. Populasi dan sampel adalah siswa SMP kelas VII di Kota Ambon sebanyak 149, dan diantaranya diambil 8 siswa sebagai subjek. Instrumen penelitian ini terdiri dari; GEFT berbasis Ilustrasi Budaya Ambon, tes pemahaman konsep, lembar observasi, pedoman wawancara. Analisis data menggunakan analisis kuantitatif dan kualitatif menggunakan nVivo. Hasil penelitian menunjukkan bahwa siswa dengan gaya kognitif *field independent* (FI) mencapai skor pemahaman konsep rata-rata 86,6, lebih tinggi dibandingkan siswa *field dependent* (FD) dengan rata-rata 79,2. Selain itu, konteks budaya Ambon (sistem barter dan rumah Baileo) secara signifikan membantu siswa FD dalam mengonkretkan konsep perbandingan melalui scaffolding dan diskusi kelompok. Selanjutnya, keterlibatan afektif siswa yang meningkat melalui integrasi etnomatematika.

Kata kunci: Budaya Ambon, Pola Kognitif; Pemahaman Konsep; Etnomatematika; Pembelajaran Berbasis Masalah

Abstract

This study aims to analyze students' cognitive patterns and understanding of mathematical concepts in problem-based learning that integrates ethnomathematics, in comparison with materials that do not. This study uses a mixed method with quantitative data in the form of concept comprehension scores and qualitative data in the form of code networks and concept maps that represent the relationship between the learning process, the Ambon cultural context, and students' affective responses. The population and sample are 149 junior high school students in Ambon City, and among them, 8 students were taken as subjects. The instruments of this research consist of: GEFT based on

Ambon Cultural Illustration, concept comprehension tests, observation sheets, and interview guidelines. Data analysis uses quantitative and qualitative analysis using NVivo. The results showed that students with field independent (FI) cognitive styles achieved an average concept comprehension score of 86.6, higher than field dependent (FD) students with an average of 79.2. In addition, the cultural context of Ambon (barter system and Baileo houses) significantly helped FD students in concretizing the concept of comparison through scaffolding and group discussions. Furthermore, student affective engagement is increased through ethnomathematical integration.

Keywords: Ambon Culture; Cognitive Patterns; Concept Understanding Ethnomathematics; Problem-Based Learning

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INTRODUCTION

Ideally, mathematics learning should not only be oriented to learning outcomes, but also to how the information is obtained by students and the understanding of the mathematical concepts that are built (Onyebuchi & Norman, 2014). Concept understanding is the ability to understand the meaning of concepts, operations, and mathematical relationships, as well as to see the relationship between facts, procedures, and ideas to form a coherent wholeness (NCTM, 2020). With a good understanding of concepts, students will be able to reason, understand, operate, and connect mathematical ideas that will play a role in solving problems (Nisa et al., 2022). Saleh Haji explains that understanding of concepts in mathematics can be developed through: defining concepts verbally and in writing, using examples instead of words, using symbols to represent concepts, changing the form of representation to different forms, identifying the characteristics of a concept, comparing different concepts, and interpreting concepts (Saleh Haji, 2019).

But sometimes students with their cognitive style find it difficult to understand mathematical concepts. Therefore, it is necessary to pay attention to the cognitive style of students. According to Witkin, cognitive styles/patterns can be distinguished into several types, including *Field Independent* (FI) and *Field*

Dependent (FD) cognitive styles (Witkin et al., 1975). Cognitive patterns are an important aspect in this context that affects the success of learning mathematics, especially FI and FD styles (Fina Hanifa Zaena, 2025; Wijayaningrum et al., 2024). Differences in students' cognitive patterns, especially FI and FD styles, are one of the main factors that affect mathematics learning in the classroom (Syafiti et al., 2022; Takdirman, 2023). Cognitive patterns reflect ways of thinking, organized information, and problem-solving that vary between individuals and are influenced by cultural backgrounds, learning environments, and previous learning experiences (Takdirman, 2023).

Mathematics learning in Indonesia, especially in Ambon City, often focuses on procedures and final results, not on students' cognitive processes. This causes many students to have difficulty understanding the conceptual meaning and application of mathematics in daily life. Even though understanding concepts is the main key to developing high-level thinking skills and mathematical literacy (Sudarmin et al., 2025). Therefore, it is very important in the city of Ambon to use a learning approach that is able to integrate cultural contexts and activate cognitive processes in mathematics education.

The contextual approach offered by ethnomathematics places local culture as a source of knowledge and a means of learning (Pusvita et al., 2019; Salsabila Santoso et al., 2025; Sopamena et al., 2026a; Yudhi & Septiani, 2024). The development of critical, reflective, and creative thinking skills that integrate ethnomathematics in problem-based learning provides opportunities for students through the exploration of cultural values in mathematical solving (Salsabila Santoso et al., 2025; Yudhi & Septiani, 2024). This approach is believed to enrich the meaning of learning and increase the connection between school mathematics and the socio-cultural resiliency of the community. However, the compatibility between students' cognitive patterns and the learning strategies used is the basis for making ethnomathematics-based learning effective (Salsabila Santoso et al., 2025; Yudhi & Septiani, 2024). Therefore, how cognitive patterns play a role in the formation of understanding of mathematical concepts is important to be studied more deeply through an integrated ethnomathematical problem-based approach.

Research on ethnomathematics in Maluku by (Sopamena et al., 2026b) shows the effectiveness of LKS based on local Maluku wisdom in improving the quality of mathematics learning. A study of FI and FD cognitive patterns in PBL (Son et al., 2020; Syafiti et al., 2022) which revealed the differences in problem-solving strategies between the two cognitive styles. In addition, ethnomathematics integrated PBL meta-analysis research (Imroatus Sholihah, 2025) confirms the effectiveness of this approach in improving mathematical literacy. Furthermore, a study of the implementation of local culture in the Merdeka curriculum by (Salsabila Santoso et al., 2025) shows that the cultural context reinforces the meaning of learning.

These studies have not specifically examined how the cognitive patterns of FI and FD interact differently with the local cultural context of Ambon in the process of constructing understanding of mathematical concepts. The novelty of this research lies in the use of specific Ambon culture as a contextual stimulus that is analyzed through two lenses at once: cognitive patterns and understanding of mathematical concepts.

This research uses cultural elements, such as the Baileo House as a symbol of equality and proportion in traditional architecture that is relevant to the concept of comparison; The barter system is a local economic practice that inherently contains the concept of value comparison and value reversal; and Kora-kora Boat as a context for comparing speed and time that is familiar to Ambon students. The selection of these elements is based on the principle that a cultural context close to the student's daily life will activate the existing cognitive schema (prior knowledge), thus facilitating the process of assimilation and accommodation of new mathematical concepts (Piaget, 2008).

This research is expected to provide a theoretical and practical contribution for teachers and curriculum designers in understanding the cognitive characteristics of students in the city of Ambon to develop a culture-based mathematics learning model. Thus, the results of this research can be the basis for designing learning that is more inclusive, contextual, and oriented towards an in-depth understanding of mathematical concepts.

METHOD

This study used a mixed methods design with a sequential explanatory design (Creswell & Creswell, 2018). At the quantitative stage, as many as 149 grade VII students from three schools (MTs N Ambon, SMP Cendekia Ambon, and MTs Al Khairat Ambon) participated. At the qualitative stage, 8 students were selected using purposive sampling techniques based on two criteria: (a) the cognitive category of GEFT results (FI or FD), and (b) the level of conceptual understanding (high, medium, low) based on the test results. Each of 4 students represented the FI group and 4 students represented the FD group. Furthermore, 8 students were analyzed in depth through interviews and class observations to obtain a thick description of the process of forming concept understanding based on their respective cognitive patterns.

This research instrument has gone through an expert judgement process by two experts in mathematics education and one local cultural expert in Ambon. The concept comprehension test was validated based on the (NCTM, 2020) indicator and tested for reliability using the Cronbach Alpha coefficient ($\alpha = 0.82$). The GEFT used is a standard instrument from (Witkin et al., 1975) which has been adapted to the illustration of Ambon culture through a content validation process.

Mathematics learning using PBL integrated with Ambon Culture is implemented in the following order:

1. The problem orientation phase, where the teacher presents contextual problems based on Ambon culture (for example, the barter scenario in the Ambon traditional market).

2. In the organizational phase of learning, students discuss in small groups (4–5 people) to identify known information and plan a solution strategy.
3. In the investigation phase, students explore the concept of comparison through a real context (calculating barter exchange rates, analyzing the speed of Kora-kora boats).
4. In the development and presentation phases of results, students present solutions and relate them to formal mathematical representations.
5. In the analysis and evaluation phase, the teacher provides reinforcement and feedback.

Quantitative data were analyzed using descriptive statistics (mean, percentage) and FI-FD group difference tests. Qualitative data were analyzed using the (Miles & Huberman, 1994) model through three stages: data reduction, data presentation, and conclusion drawn, with the help of NVivo 12 software. The validity of the data is ensured through methodological triangulation (comparison of data from tests, observations, and interviews) and member checking with mathematics teachers involved in the research.

RESULT AND DISCUSSION

Based on the data of this study, the mindset or cognitive style and its relationship with the quantitative data of students' mathematical concept understanding scores can be grouped into the field independent (FI) and field dependent (FD) groups. Based on data from 149 students in grade VII of junior high school, as seen in Table 1 below.

Table 1. Percentage of Cognitive Patterns and Average Concept Comprehension Scores

Student	FD	FI
Group percentage	12,8%	87,2%
Average Understanding of concepts	79,2	86,6

Of all the students who were the subjects of the study, most of them, namely 87.2%, were classified as Field Independent (FI), while only 12.8% were classified as Field Dependent (FD). This suggests that the dominance of FI cognitive style was very large in the study sample. FI students obtained an average concept comprehension score of 86.6, while FD students obtained 79.2. The difference was 7.4 points, which shows that FI students tend to be superior in understanding mathematical concepts than FD students.

Based on these data, students' concept comprehension scores are in the high–medium range, with FI students tending to obtain higher average scores than FD students, especially in the indicators of defining, representing, and applying comparisons in new contexts. However, the variation in scores from each group showed that the difference in ability was determined not only by cognitive style but also by students' involvement in local culture-based discussions and problem-solving (Ambon). This is supported by cognitive style theory, which explains that FI students tend to be able to organize information independently, focus on the internal structure of the problem, and be stronger in abstraction, while FD students rely on external context and social support in understanding problems (Afifah et al., 2022; Hardiansyah et al., 2024; Hasbullah & Sajiman, 2020)Qualitative data mapping using nVivo analysis through project maps and mind maps shows that students' understanding of mathematical concepts develops through three clusters, namely: 1) concept understanding (understanding the meaning of comparisons, making examples, and solving problems); 2) the learning process (PBL problem-solving activities that relate the Ambon cultural context); 3) affective experience (feeling happy and motivated). As the following interview excerpt:

Q: Can you give examples from daily life?
A: For example, the value comparison is bartering 1 milk powder with 1 pack of malkist, while the comparison reverses the value, for example, the speed/time of the kora-kora boat race.

The network of codes shows a strong network between the codes of "concept understanding" and codes of "making examples", "solving problems", "Ambon culture", and "comparative material", which indicates that conceptual understanding is formed through the simultaneous linkages between cognitive activities, cultural contexts, and classroom dynamics(Batubara, 2023; Hasbullah &

Sajiman, 2020; Son et al., 2020).

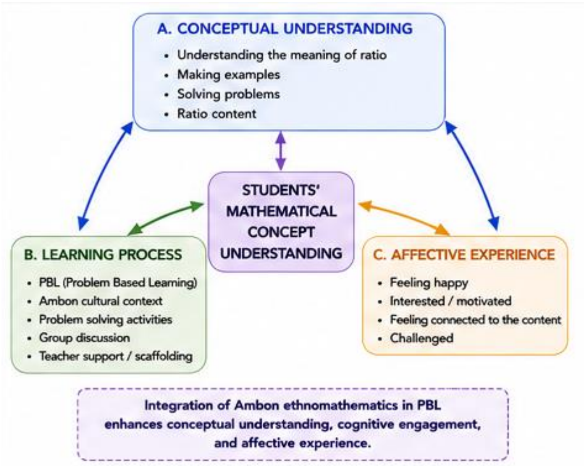

Figure 1. Project Map Factors Affecting Students' Understanding of Mathematics Concepts

The project map from NVivo's analysis shows that students' understanding of mathematical concepts is formed through the relationship between cognitive aspects, learning processes, and affective experiences. The cognitive aspect is reflected through the ability to understand the meaning of comparisons, make examples, and solve problems. The learning process that utilizes Problem Based Learning based on the context of Ambon culture is the main means of building this understanding. In addition, affective experiences in the form of pleasure, learning motivation, and students' proximity to the material also strengthen the construction of concept understanding. These findings show that the integration of Ambon ethnomathematics in mathematics learning not only improves conceptual understanding, but also encourages students' cognitive and affective engagement simultaneously.

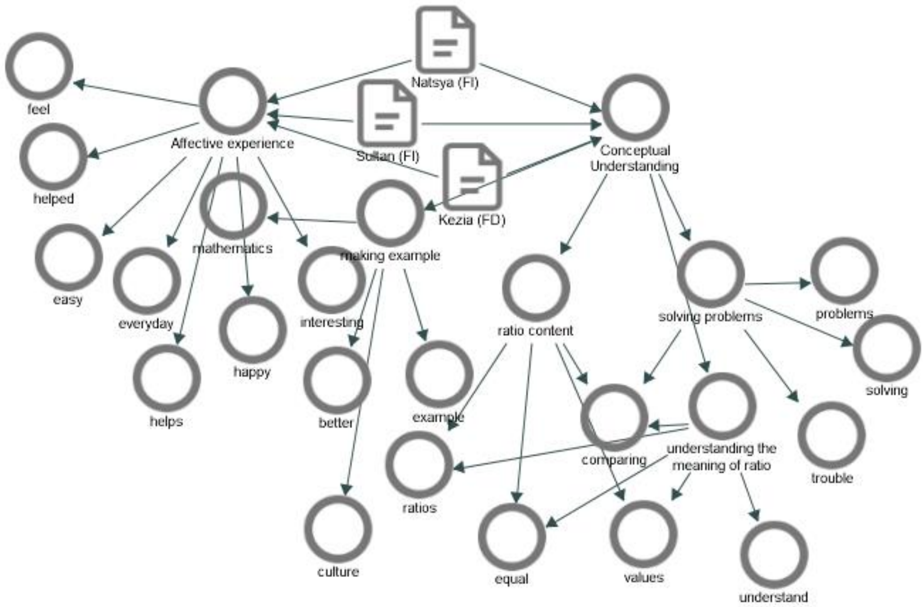

Figure 2. Concept Map Mathematical Concept Understanding and Active experence

The results of NVivo's analysis showed a strong relationship between affective experience and students' understanding of mathematical concepts. The Affective Experience node is connected to codes such as happy, interesting, easy, helps, and everyday, which indicates that students feel a positive learning experience during Ambon's ethnomathematics-based learning. These affective experiences contribute to the formation of Conceptual Understanding which is reflected in the ability to understand the meaning of comparisons, make examples, compare values, and solve problems. These findings suggest that the cultural context of Ambon not only increases students' emotional engagement, but also helps them build a deeper and more meaningful understanding of mathematical concepts.

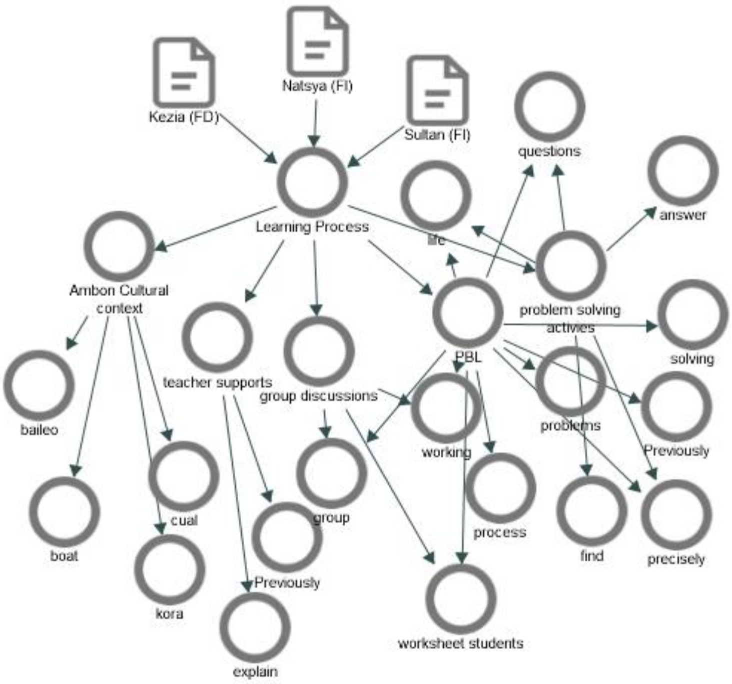

Figure 3. Concept Map Learning Process

The results of the visualization show that the Learning Process theme is formed through the relationship between Problem Based Learning (PBL), the Ambon cultural context, problem-solving activities, group discussions, and teacher support. Cultural contexts such as baileo and kora-kora boats serve as sources of problems relevant to students' lives. Problem-solving activities encourage students to ask questions, find solutions, and verify answers systematically. In addition, group discussions and teacher support act as scaffolding mechanisms that help students construct understanding collaboratively. These findings suggest that the integration of ethnomathematics in PBL creates an active, contextual, and meaningful learning environment for students.

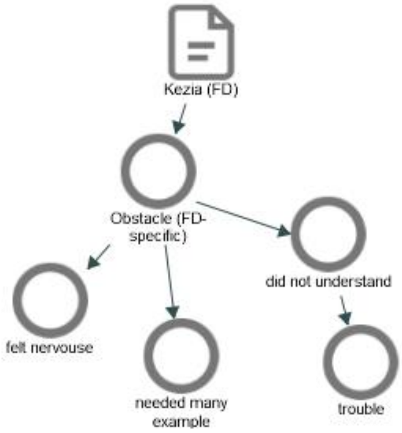

Figure 4. Concept Map Obstacle (FD-specific)

Analysis of the Obstacle cluster (FD-specific) showed that Field Dependent students experienced several obstacles in understanding mathematical concepts, which were characterized by the emergence of codes 'did not understand', 'felt nervous', and 'needed many examples'. The relationship between 'did not understand' and 'trouble' codes indicates that difficulty understanding concepts is the main source of difficulty in solving mathematical problems. In addition to the cognitive aspect, students also show an affective response in the form of nervousness when facing material that has not yet been understood. These findings suggest that FD students need more structured learning support, including the use of concrete examples, teacher scaffolding, and familiar cultural contexts to aid the conceptual understanding construction process.

The following matrix maps the relationship between the stages of PBL integrated with Ambon Culture, indicators of concept understanding (defining, representing, applying, generalizing), and the characteristics of FI/FD cognitive patterns that appear at each stage.

Table 2. Matrix Maps the Relationship Between the Stages of PBL Integrated with Ambon Culture

Stages of PBL Integrated with Ambon Culture	Concept Understanding Indicators	Characteristics of the Cognitive Patterns
PHASE 1 Contextual Problem Orientation Phase *The problem of barter & comparative value system in the traditional market of Ambon* Cultural stimulus	Defining concepts: Identifying comparisons from the context of barter Recognize examples: Differentiate value vs. value reversal	FI instantly abstracts comparison patterns without relying on visual context FI is quick to make initial hypotheses about the type of comparison
PHASE 2 Organization & Learning Planning *Group discussion: strategizing from the context of Baileo and local exchange rates*	Classify: group comparison types based on their proportional properties Represent: expressing concepts in simple mathematical sentences	FI takes an analytical role in the group, classifying data independently - FI Articulate a solution strategy before discussion - FD relies on group interaction to validate initial understanding and the teacher's role as a scaffolder in this phase is critical to FD success - Baileo's cultural discussion brought up conceptual connections in both groups (FI and FD)
PHASE 3 Investigation & Exploration: calculating the barter value, the speed of the Kora-kora boat, and	Applying: using the concept of comparison to the real situation of Ambon culture	FI is able to extract mathematical patterns from cultural contexts independently

Stages of PBL Integrated with Ambon Culture	Concept Understanding Indicators	Characteristics of the Cognitive Patterns
the architectural proportions of Baileo Enactive to iconic	Compare: differentiate value comparison (barter) vs value reversal (speed/time)	- FI performs representation abstraction: from story to formula quickly - average FI score: 88.4 (higher than FD's 78.7) - FD needs step-by-step guidance: guiding questions to calculations to generalizations - FDs encounter obstacles that arise when moving from concrete contexts to symbolic representations - The context of Kora-kora & barter increases the affective involvement of both groups (FI and FD)
PHASE 4 Expansion & Presentation of Results *Presentation of solutions and linking to formal mathematical representations* Iconic to symbolic	Represent: Present a solution in the form of a table, graph, or equation Interpreting: Explaining the meaning of the results of the calculation in a cultural context	Presentations are analytically structured, connecting examples to general principles (FI) - FI is able to produce symbolic representations without external assistance - FD is more comfortable presenting a narrative based on cultural stories than a formal formula - The symbolic representation of FD increases significantly after scaffolding phases 2–3 - The involvement of Ambon culture increased the confidence of both groups during the presentation (FI and FD)

Stages of PBL Integrated with Ambon Culture	Concept Understanding Indicators	Characteristics of the Cognitive Patterns
PHASE 5 Analysis, Evaluation & Generalization *Reinforcement of concepts, teacher feedback, and the drawing of universal mathematical conclusions* Symbolic to generalization	Generalizing: formulating comparative principles that apply outside the context of Ambon culture	FI is able to abstract mathematical principles from culture into universal formulas
	Evaluate: check the correctness of the solution and identify conceptual errors	- FI reaches the formal operational stage faster (average generalization score of 89.1) - FI actively identifies and corrects peers' conceptual errors - FD generalization is achieved with the support of guiding questions from teachers - FD epistemological barriers are reduced after being given additional cultural analogy examples - Average final score: FI = 86.6 | FD = 79.2 (7.4 point difference) (FI and FD)

FI students more quickly reach the formal operational stage in generalizing the concept of comparison explained through the concept *of equilibration* and *decentering ability* (Piaget, 2008). Improving FD students' understanding through scaffolding and group discussions is described within the framework *of the Zone of Proximal Development* (ZPD) (Vygotsky, 1978). The cultural context of Ambon serves as *a mediating artifact* that helps students transcend their ZPD. The use of enactive representations (barter simulations), iconic (illustrations of Baileo and Kora-kora), and symbolic representations (comparative formulas) in PBL show the application of the stages of Bruner representation in a spiral manner (J. Bruner, 2021; J. S. Bruner, 1972).

In the FD student group, the data showed that the success of conceptual understanding was more pronounced when the teacher provided clear structural support (Son et al., 2020). However, the study expands on these findings by showing that the specific local cultural context can reduce the epistemological barriers of FD students through affective pathways, a dimension that has not been discussed in depth by previous research. The use of concrete representations of cultural practices (e.g., illustrations of the barter system), as well as group work that allowed for collaborative discussion and clarification of meaning. Meanwhile, the FI student group tends to use cultural cues as a trigger to generalize and formalize the concept of comparison into symbolic and procedural forms, and be more independent when dealing with non-routine problems (Imroatus Sholihah, 2025; Sangadah et al., 2025; Sumaji et al., 2025).

In general, the integration of ethnomathematics in PBL enhances cognitive and affective engagement: students report feeling happy, challenged, and closer to the material because problem situations are considered relevant to their daily lives. As stated by the following students:

Q: How do you feel during this math lesson?
A: I felt very happy because I was able to get to know some of the culture of Ambon
Q: What is the most interesting thing about learning today? Why?
A: What is interesting about this lesson is to association Ambon culture with comparisons

This is reflected in the strengthening relationship between the code of "feeling happy", "Ambon culture", and "the learning process that is directly connected to the "understanding of concepts" in the mind map, so that emotional support from the cultural context seems to act as a catalyst for the construction of meaning. This means that the affective domain in mathematics learning shows that positive emotions such as enjoyment are related to mathematical self-concepts, perception of mathematical values, teacher support, and learning efforts, all of which predict engagement and achievement. It also indicates that a familiar and relevant cultural context increases students' sense of value and confidence in facing challenging math problems (Aulia Hamidiyah & Wamer Erliana, n.d.; Bintoro et al., 2024; Daher, 2022; Imroatus Sholihah, 2025). Thus, it is hoped that teachers can design problem-based learning by integrating students' local culture in improving students' understanding of concepts and paying attention to students' cognitive patterns.

CONCLUSION

Based on the results of the research and discussion, then it can be concluded that the main characteristics of students' cognitive patterns: (a) FI students tend to build an understanding of concepts independently through processes of abstraction and generalization sourced from cultural stimuli, while (b) FD students require gradual scaffolding and familiar cultural contexts as a bridge between concrete experiences and formal mathematical representations. This study is still limited to: (a) the sample is limited to three schools in Ambon City so generalizations need to be done carefully; (b) the implementation of PBL only lasts 4 meetings so that the long-term effects cannot be measured; (c) qualitative analysis involves only 8 subjects.

With these limitations, it is recommended to teachers that in the face of FD students who experience obstacles, teachers can provide *local* culture-based problem cards equipped with multi-level scaffolding (from simple guide questions to generalization questions), so that students can move gradually from concrete to abstract contexts. For the next researcher, conduct research in other areas of Maluku (e.g. Ternate or Seram) with the exploration of different cultural elements, to test whether similar patterns of findings arise in the broader context of Maluku culture.

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