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# Profile of Mathematical Connection Ability Viewed from The Cognitive Styles of Field Independent and Field Dependent Students

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**ABSTRACT**

This study aims to describe the profile of students' mathematical connection ability, as viewed through the cognitive styles of Field Independent (FI) and Field Dependent (FD), in the topic of Social Arithmetic. The research subjects were 32 students of class VIII-B at SMPN 1 Cimalaka. Cognitive style classification was conducted using the Group Embedded Figure Test (GEFT), after which students completed a mathematical connection ability test comprising three contextual problems that required integrating concepts (direct proportion, percentage, currency exchange, and profit/loss) and connecting mathematics to real-life contexts. Data were analyzed using a descriptive qualitative approach through data reduction, data display, and conclusion drawing. The results showed that the cognitive style composition consisted of 14 FI students (43.75%) and 18 FD students (56.25%). Mastery based on the minimum competency criterion (KKTP 75) indicated that the FI group achieved a higher level of mastery (12 students) compared to the FD group (1 student), while non-mastery was predominantly found in the FD group (17 students). These findings indicate that FI students tend to be more consistent in integrating concepts to produce complete solutions and final decisions. In contrast, FD students require more supportive structures (tables, step-by-step procedures, and guiding questions) for mathematical connections to be fully developed.



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## 1. INTRODUCTION

Mathematics education in the 21st century requires students not only to master procedures but also to construct relationships among concepts so that this knowledge can be applied in various life situations. The *Merdeka Curriculum* implemented in Indonesia emphasizes meaningful learning, namely learning that encourages students to think critically, creatively, and reflectively through problem-solving activities [1]. In this context, mathematical connection ability becomes one of the higher-order thinking skills that plays a crucial role. This ability refers to the skill of linking mathematical concepts within a single topic and across topics, connecting mathematics with other disciplines, and relating it to real-life situations. The *Merdeka Curriculum* provides strong support for improving students' mathematical concepts. In this way, students have better opportunities to master mathematics deeply and effectively [2].

Mathematical connection ability plays a strategic role in building a strong, well-organized knowledge structure. Based on the interpretation of NCTM, the indicators of mathematical connection ability include: (1) recognizing and using relationships among ideas in mathematics; (2) understanding how mathematical ideas are interconnected and form a coherent whole; and (3) applying mathematics in contexts outside mathematics [3]. The indicators of mathematical connection ability include: (1) connections among mathematical topics; (2) connections between mathematics and other fields; and (3) connections between mathematics and everyday life [4]. Students who can perceive the interconnectedness of concepts tend to understand new ideas more easily because they can link them to prior knowledge.

Students with strong connection abilities tend to be more successful in solving open-ended problems and demonstrate greater cognitive flexibility. However, various studies at the secondary school level indicate that this ability has not yet developed optimally [5]. Most students can connect concepts within a single topic but are unable to extend these connections to other areas of mathematics or to contextual situations [6]. Mathematical connections play an important role as a tool for students in solving mathematical problems because they allow students to relate concepts across topics and apply them in new contexts; thus, this ability serves as a key indicator of higher-order mathematical thinking [7].

These conditions indicate that mathematical connection ability does not emerge automatically but requires a learning process that accounts for students' diverse ways of thinking. One factor believed to influence the development of connections is cognitive style. Cognitive style describes an individual's tendency to attend to, process, and organize information. Students with a field-independent cognitive style are generally better at separating relevant information from complex contexts, while field-dependent students tend to view information holistically and often have difficulty identifying important details [8]. Students with certain cognitive styles tend to be better able to connect transformation concepts to word problems [9].

Several studies indicate a relationship between certain cognitive styles and mathematical connection ability. Students with a field-independent style are generally more successful at explaining relationships among concepts and solving contextual problems [10]. However, these findings are not entirely consistent. This aligns with Fortuna (2021), whose study examined Field Independent (FI) and Field Dependent (FD) styles in relation to mathematical connection ability and found that FI students tend to outperform FD students on several connection indicators, particularly in applying mathematics to real-life situations.

Field-Dependent (FD) students can build strong connections when learning in collaborative, problem-based environments. This finding suggests that the relationship between cognitive style and mathematical connection ability is complex and may be influenced by learning context, material characteristics, and the types of tasks given [11]. FD thinkers often demonstrate contextual connections when answering word problems by linking them to real-life experiences, even though their responses are less structured than those of FI students [12].

Although a number of studies have examined these two variables, existing research still has several limitations. First, many studies focus on only one dimension of cognitive style, such as reflective or impulsive, without considering other dimensions, such as field dependence or independence [6]. Second, some studies use descriptive designs with limited sample sizes, making the findings difficult to generalize [13]. Third, most studies assess mathematical connection ability in only one type of material, even though this ability may vary across topics. Fourth, there are still a few studies that present detailed profiles of students' mathematical connection abilities.

## 2. METHOD

This study employs a qualitative descriptive research design. The selection of this approach aims to obtain an in-depth description of students' mathematical connection ability profiles based on their cognitive styles, rather than to test hypotheses or determine causal relationships. Through a qualitative approach, researchers can explore students' thinking processes naturally as they solve mathematical problems and observe how they construct connections among concepts. In addition to a mathematical connection ability test, interview sessions were conducted to explore students' thinking processes when solving mathematical connection problems. The interview questions focused on how students understand relationships among concepts, the reasons for selecting certain strategies, and the difficulties they experience during the problem-solving process. The research process begins with developing open-ended mathematical connection problems and designing in-depth interview guidelines to explore students' thinking processes when connecting concepts [14].

Before administering the mathematical connection ability test, students were given a cognitive style test using the GEFT (Group Embedded Figure Test) to distinguish between Field-Independent (FI) and Field-Dependent (FD) students. The GEFT is a group version of the Embedded Figures Test (EFT) used to assess an individual's ability to filter, structure, and extract essential elements from complex visual contexts. This ability represents the core distinction between individuals with Field-Independent (FI) and Field-Dependent (FD) cognitive styles [15].

The construction of test items was based on the indicators of mathematical connection ability proposed by NCTM, which include: (a) the ability to connect ideas within a single topic; (b) the ability to connect concepts across different mathematical topics; and (c) the ability to connect mathematics with other fields or with everyday life [3]. The research design was adapted from the qualitative analysis model, which consists of three main components: data reduction, data display, and conclusion drawing and verification. These three stages occur interactively and iteratively throughout the research process, ensuring that the resulting interpretations remain consistent with the collected data [16].

The research subjects were students of class VIII-B at SMPN 1 Cimalaka. This grade level was chosen because students have already studied various mathematical topics such as

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integers, algebra, and ratios, which allows the researcher to assess their ability to connect concepts across topics. After determining the research subjects, students were given the GEFT to identify their cognitive styles and classify them as FI or FD. Following the classification of cognitive styles, students were administered a mathematical connection ability test comprising three questions on Social Arithmetic. These questions required students to connect concepts across mathematical topics, such as linking social arithmetic with direct proportion, connecting mathematics with currency values studied in Social Studies, and applying mathematics to real-life contexts.

The data presentation stage was conducted after the data reduction process and presented the results in concise narrative descriptions. Finally, conclusion drawing and verification were conducted to interpret the findings and describe the profile of students' mathematical connection abilities in terms of their cognitive styles.

## 3. RESULTS AND DISCUSSION

### 3.1. Results

The following are the results of the GEFT test for students of class VIII-B at SMPN 1 Cimalaka.

Table 1. Results of the Cognitive Styles of Class VIII-B Students

| Cognitive Style | Number of Students | Percentage |
|---|---|---|
| Field Independent (FI) | 14 | 43.75% |
| Field Dependent (FD) | 18 | 56.25% |
| Total | 32 | 100% |

Based on the table above, 14 students (43.75%) belong to the Field Independent (FI) group, while 18 students (56.25%) are classified as Field Dependent (FD). The total number of students involved in this study is 32. The following table presents the results of students' mathematical connection abilities, as viewed through their cognitive styles, in class VIII-B at SMPN 1 Cimalaka.

Table 2. Results of the Mathematical Connection Ability Test Viewed from Cognitive Style

| Cognitive Style | Achieved Mastery | Not Achieved Mastery |
|---|---|---|
| Field Dependent (FD) | 1 student | 17 students |
| Field Independent (FI) | 12 students | 2 students |

Based on the table above, four potential groups of students can be used as sources for discussion:

1. Field Independent (FI) students who achieved mastery in solving mathematical connection problems.
2. Field Independent (FI) students who did not achieve mastery in solving mathematical connection problems.
3. Field Dependent (FD) students who achieved mastery in solving mathematical connection problems.

4. Field Dependent (FD) students who did not achieve mastery in solving mathematical connection problems.

Mastery refers to the Criteria for Learning Objective Achievement (KKTP) determined by the school, which is 75. To provide an intense discussion, four main subjects were selected to represent all variations. These include student S11, who belongs to the Field Independent (FI) group and shows the highest representation of mathematical connection ability; student S27, who is also FI but whose performance is not yet optimal and is therefore interesting to analyze in terms of the contributing factors; student S20, who belongs to the Field Dependent (FD) group and achieved mastery on the mathematical connection ability test; and student S2, who was selected because they did not achieve mastery. The table below shows the achievement of mathematical connection ability indicators based on students' cognitive styles, as reflected in their performance on each indicator when solving mathematical connection problems.

Table 3. Scores for Each Indicator of Selected Students and Their Mastery Status

| Subject Code | Indicator 1 Score | Indicator 2 Score | Indicator 3 Score | Total Score | Mastery | Cognitive Style |
|---|---|---|---|---|---|---|
| S11 | 3 | 3 | 4 | 10 | Achieved | FI |
| S27 | 3 | 3 | 2 | 8 | Not Achieved | FI |
| S20 | 2 | 4 | 3 | 9 | Achieved | FD |
| S2 | 0 | 2 | 2 | 4 | Not Achieved | FD |

From Table 3 above, it can be seen that four students were selected as subjects for further discussion. Student S11 belongs to the Field Independent (FI) cognitive style group and achieved mastery. The second subject, S27, is also a Field Independent (FI) student, but did not achieve mastery. The third subject, S20, belongs to the Field Dependent (FD) cognitive style group and achieved mastery. The last subject, S2, belongs to the Field Dependent (FD) cognitive style group and did not achieve mastery.

## 3.2. Discussion

**Profile of Mathematical Connection Ability Viewed from Cognitive Style for Subject S11 (Field Independent, Achieved Mastery)**

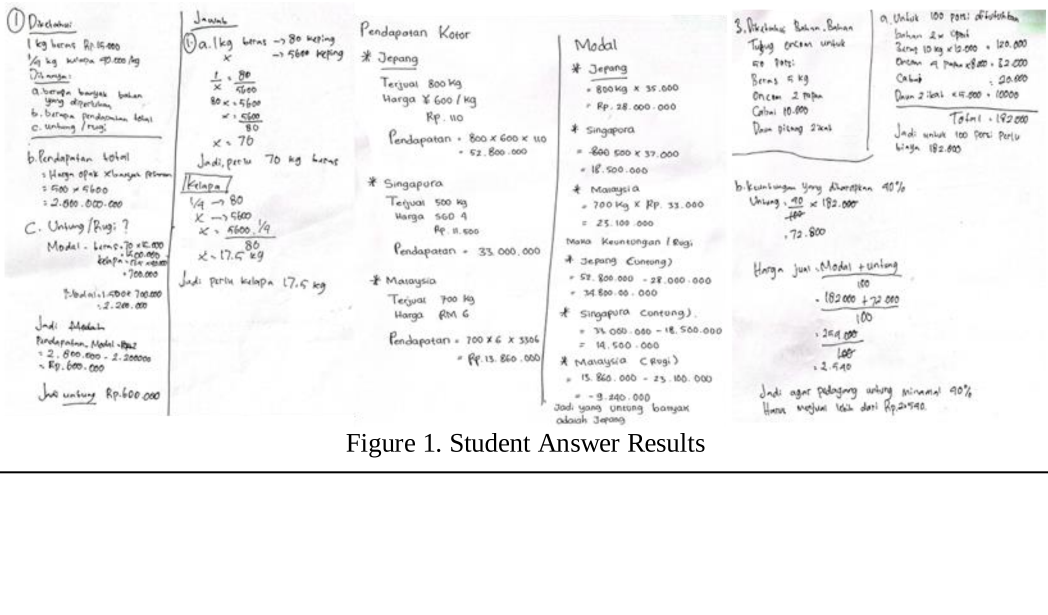

Figure 1. Student Answer Results

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Based on the student's answer image, S11 answered question 1 with strong mathematical reasoning and identified important information in the problem. The student was able to connect the problem to the previously learned concept of direct proportion. The calculation steps were generally logical; however, corrections were needed at the final stage to address computational errors, which led to an incorrect conclusion. In line with this finding, Wijayaningrum states that FI students are more capable of identifying relevant information, organizing their strategies, and presenting appropriate representations, thereby increasing their likelihood of achieving scores above the minimum mastery criteria [17].

Regarding question number 2, S11 demonstrated mathematical connection ability in linking mathematics with other fields of knowledge (external connections). Based on the student's response, S11 identified essential information in the problem and connected it to the conversion of foreign currency values, which had previously been learned in Social Studies (IPS) lessons on foreign exchange rates. The calculation steps were generally logical, although there were some errors at the final calculation stage. Based on the answer to question number 3, S11 demonstrated very strong mathematical connection ability and was able to identify important information in the problem. The student successfully connected the problem to real-life phenomena (contextual connections). The calculation steps were logical, systematic, and accurate.

Overall, the interview results indicate that S11 (FI) tends to: (1) begin by identifying what is known and what is asked; (2) organize solution procedures in a systematic sequence; (3) maintain consistency in units and relationships among quantities (income–cost–profit); and (4) complete the solution up to a conclusion or decision. This pattern reflects well-developed mathematical connection ability across internal, external, and contextual dimensions, thereby supporting the achieved mastery classification in the test results.

**Profile of Mathematical Connection Ability Viewed from Cognitive Style for Subject S27 (Field Independent, Not Achieved Mastery)**

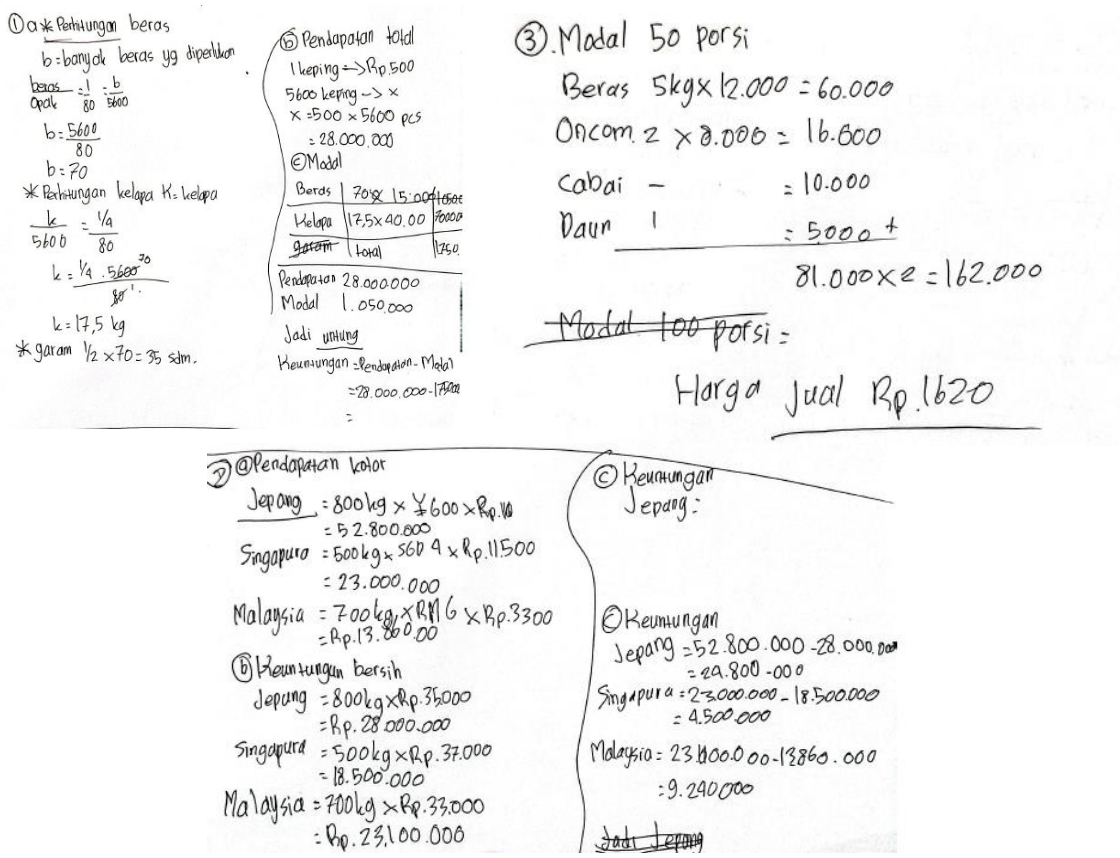


Figure 2. Student Answer Results

Based on the student S27's work shown in Figure 2, the student demonstrated strong mathematical connection ability. The student was able to connect several mathematical concepts internally, namely ratios, units, and basic arithmetic (addition, subtraction, and multiplication). The solution steps carried out by the student appear logical and systematic; however, there were errors in determining the total income and in concluding. As a result, student S27 did not obtain the maximum score for this problem.

Based on the student's response in Figure 2, the student was able to construct internal connections by integrating several mathematical procedures, such as calculating gross income from mass (kg) × price (with currency conversion) and continuing to calculate profit by subtracting capital from income. The student also demonstrated external connections (mathematics–economics) by using concepts of price, exchange rates, and profit/loss to compare profits across countries (Japan, Singapore, and Malaysia). In context, the solution represents a real-life situation involving cross-border transactions or sales.

However, although the calculation steps were logical and the numerical results appeared consistent, the student did not write a conclusion (for example, which country was the most profitable or the final decision requested by the problem). Because the element of result confirmation (conclusion) was absent, this response is more appropriately scored 3. According to Buhaerah [18], in the problem-solving process, students need to "present solutions and evaluate their accuracy"; concluding is an essential part of reviewing and validating the final results.

Based on the student's response in Figure 2, the student appears to have identified some information in the problem and performed several relevant calculations. The student determined the total cost of ingredients for 50 portions of nasi tutug oncom, then doubled it to obtain an estimated cost for 100 portions. However, the student's work did not yet demonstrate complete mathematical connection ability. The student only completed the calculation of production costs (capital) without proceeding to determine the selling price with a 40% profit, as required in part (b) of the problem. In addition, the student did not provide an explanation or a conclusion for the calculations' results. Thus, the connections shown cover only part of the required concepts, without integrating all the information and relationships demanded by the problem context.

According to the Mathematical Connection Scoring Guidelines, the student's performance meets the criteria for a score of 2 because not all aspects of the problem (profit and selling price) were completed, resulting in an incomplete outcome. This finding is consistent with Sumarmo [19], who states that mathematical connection ability requires students not only to understand concepts in isolation but also to connect multiple concepts to obtain a complete and meaningful solution. When students stop at the stage of calculating capital without linking it to the ultimate goal (determining the selling price with a certain profit), their mathematical connection process cannot be considered complete.

Overall, the interview results indicate that S27 (FI) has an analytical tendency: the student can identify what is known and what is being asked, select relevant concepts such as proportion, exchange rates, and profit–loss, and understand the relationship between income, capital, and profit. However, the "not achieved mastery" classification is likely due to: (1) procedural accuracy issues (completeness of capital components and numerical consistency), (2) incomplete final steps (especially in problems involving profit percentages), and (3) mathematical communication that does not clearly justify or confirm the appropriateness of the answer in relation to the problem instructions. These findings emphasize that having a field-independent cognitive style does not automatically guarantee mastery.

**Profile of Mathematical Connection Ability Viewed from Cognitive Style for Subject S20 (Field Dependent, Achieved Mastery)**

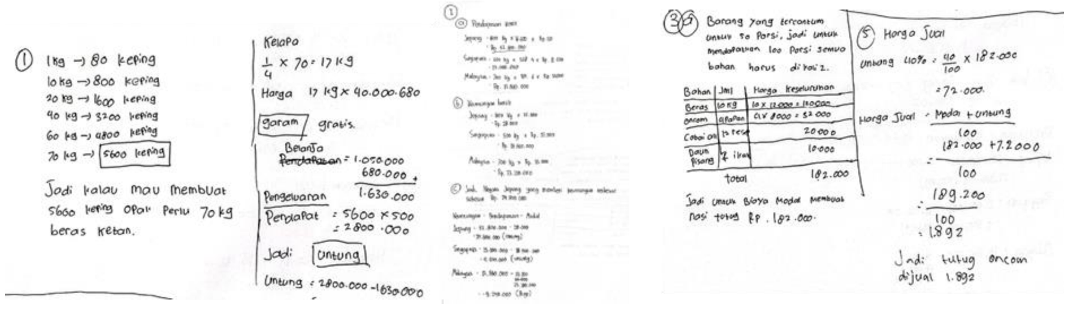

Figure 3. Student Answer Results

Based on the student's response shown in Figure 3, the student understood part of the information in the problem and correctly used several mathematical concepts. The student was able to calculate the amount of materials (glutinous rice, grated coconut, and salt) required to produce 5,600 pieces of *opak*. The calculation process indicates that the student understood the concepts of ratio and proportion, which were used to scale ingredient quantities from 80 to 5,600. In addition, the student was able to estimate production costs and total revenue from selling *opak* by multiplying the number of products by the selling price per piece.

However, the solution steps were not entirely systematic, and there were shortcomings in fully connecting the concepts. The student did not explicitly explain the process of calculating the coconut quantity and did not provide detailed units or logical reasoning underlying the final calculations. Although the conclusion of "profit" was stated, the reasoning linking the calculation results to the economic context (e.g., comparing capital and revenue) was not explained verbally or analytically. Based on the Mathematical Connection Scoring Guidelines, these characteristics correspond to a score of 2.

From the perspective of the Field Dependent (FD) cognitive style, these characteristics are highly consistent. According to Witkin, Moore, Goodenough, and Cox [15], individuals with an FD cognitive style tend to rely on external context and require explicit cues when solving problems. Based on Figure 3, which shows student S20's response to question number 2, the student demonstrated complete and correct mathematical connections. The solution flow reflects internal connections (computational operations and relationships among quantities), external connections (mathematics–economics: income, cost, profit/loss), and contextual connections (the context of MSME exports). Referring to the scoring guidelines, the student's response meets the criteria for a score of 4, namely: accurate understanding of the problem information, logical integration of multiple concepts (including exchange rates and profit/loss), systematic and accurate calculation steps, and correct final results accompanied by logical explanations or justifications.

Interestingly, this student belongs to the Field Dependent (FD) cognitive style group. Theoretically, FD learners tend to rely more on context and external cues when processing information. FD students are often supported by guidance, structured procedures, and realistic examples in building connections in mathematical thinking. In this case, the student benefited from a clear structure and realistic contexts to construct mathematical connections [20].

Based on Figure 3, which presents S20's response to question 3, the student employed an appropriate strategic approach. The student organized a cost table for 100 packages by doubling the requirements for 50 packages, then summed the material costs to obtain the total capital. Next, the student calculated a 40% profit from the capital and attempted to determine the selling price per package by dividing the total (capital + profit) by the number of packages. This pattern indicates that the student was able to connect most of the relevant concepts, suggesting a strong level of mathematical connection ability. However, in the final calculation stage, minor errors in operations or numerical accuracy remained, resulting in a selling price that was close but not entirely accurate.

When linked to the characteristics of the Field Dependent (FD) cognitive style, the student's response is also consistent: FD students generally benefit from real-life contexts and clearly presented information, enabling them to follow the problem's structure and connect the required concepts, although procedural inaccuracies may still occur. Based on the interview, S20 (FD) was able to explain the core ideas of all three problems quite clearly because the contexts were closely related to everyday life (food production, buying and selling, and exports). This made it easier for the student to identify what was known and what was asked and to follow the apparent solution flow. When asked about mastery, S20 stated that they did not stop midway because they felt it was necessary to reach the "selling price" and a "conclusion" for the answer to be complete; when uncertain, the student tended to refer back to the table and follow the sequence of steps already written. Overall, this case demonstrates that, despite having a field-dependent cognitive style, S20 achieved mastery by leveraging support from realistic contexts and structured data (tables and ordered questions) to build connections between mathematical concepts and economic contexts, extending to the decision-making stage.

**Profile of Mathematical Connection Ability Viewed from Cognitive Style for Subject S2 (Field Dependent, Not Achieved Mastery)**

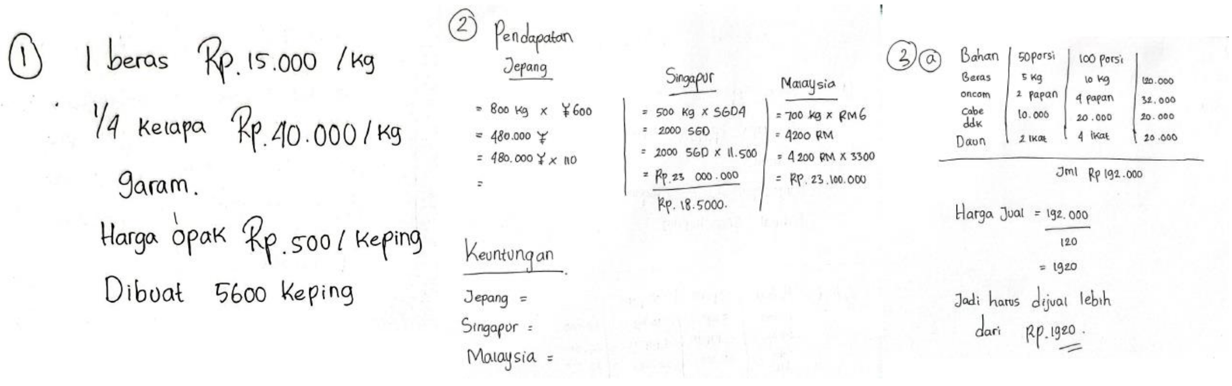


Figure 4. Student Answer Results

Based on Figure 4, which presents student S2's response to question number 1, the student merely copied or rewrote the information provided in the problem. This indicates that no process of connecting concepts was evident, and there were no mathematical steps leading toward the answers for parts (a), (b), or (c). When evaluated against the Mathematical Connection Ability Scoring Guidelines, this response scores 0 because the student did not demonstrate conceptual understanding or provide a meaningful answer, as indicated by the absence of relationships among concepts and the lack of a relevant solution.

From the Field-Dependent (FD) cognitive style perspective, this pattern remains theoretically consistent. In line with this, Witkin [15] states that FD students tend to rely on external context and often require more explicit guidance or structured steps to extract essential information and develop problem-solving strategies. In this case, the student appeared to stop at the initial stage (recording the given data), so the mathematical connections (proportion–income–profit/loss) were not formed.

Based on the student's response shown in Figure 4, S2 demonstrated partial internal and contextual connections. The student was able to initiate the income calculation by multiplying the quantity sold by the price per kilogram in local currency. However, procedural or operational inaccuracies remained evident in the other countries. In addition, the student did not proceed with the calculations for part (b) (net profit) and part (c) (determining the most profitable country); the sections labeled "Profit of Japan/Singapore/Malaysia" were left blank. This indicates that the student had not connected income with production cost per kilogram to form the concept of "profit = income − cost," nor had the student compared the results. Referring to the scoring guidelines, the characteristics of this response correspond to a score of 2, namely that the student "uses some concepts correctly, but one or two concepts are incorrect, the solution steps are incomplete, and the final result is not achieved."

Based on the response shown in Figure 4 to question 3, student S2 demonstrated a partial understanding of mathematical connections, particularly in calculating ingredient costs for 100 portions. The student attempted to double the requirements from 50 to 100 portions and calculated the cost of each ingredient. However, a procedural error occurred when doubling the number of banana leaf bundles (it should have increased from 1 to 2, but the student wrote 4), resulting in an incorrect total capital cost. This error then carried over to the determination of the selling price: the student divided the total cost of IDR 192,000 by 120 (instead of 100 packages) and did not include the required 40% profit. As a result, the final selling price of "IDR 1,920" does not reflect the problem's requirements (a 40% profit) and lacks complete conceptual connections.

## 4. CONCLUSION

Based on the results of the GEFT administered to 32 eighth-grade students of class VIII-B at SMPN 1 Cimalaka, the proportion of students with a Field Dependent (FD) cognitive style was higher (18 students; 56.25%) than those with a Field Independent (FI) cognitive style (14 students; 43.75%). However, when viewed in terms of mastery of the mathematical connection test (KKTP = 75), the FI group demonstrated substantially higher achievement, with 12 students reaching mastery and only 2 not meeting the criterion. In contrast, the FD group was dominated by students who did not achieve mastery (1 student mastered, 17 did not).

These findings reinforce the view that mathematical connection ability—which includes internal connections among mathematical ideas, external connections with other disciplines, and contextual connections with real-life situations—requires cognitive processes that can identify relevant information and integrate concepts holistically, as emphasized in the NCTM indicators of mathematical connections.

Student S11 (FI, mastered) demonstrated high achievement across all three indicators, obtaining a total score of 10. Meanwhile, S27 (FI, not mastered) achieved a lower score (total score of 8), primarily due to incompleteness and inaccuracies in the final stages of problem-solving. Student S20 (FD, mastered) reached a total score of 9 when the problems provided well-structured data and strong, realistic contexts. In contrast, S2 (FD, not mastered) exhibited fundamental weaknesses in the first indicator (score of 0), along with incomplete solution steps and conceptual errors in subsequent problems, resulting in a total score of 4.

Interpretatively, the dominance of non-mastery among FD students aligns with the characteristics of the Field-Dependent cognitive style, which tends to rely heavily on external cues or structures and has difficulty extracting essential details from complex contexts. Conversely, FI students are generally better able to structure information and systematically construct problem-solving procedures independently.

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