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PROFILE OF MATHEMATICAL REPRESENTATION ABILITY OF PROSPECTIVE MATHEMATICS TEACHERS VIEWED FROM THE COGNITIVE STYLE

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Abstract

Mathematical representation ability is needed to solve various simple and complex mathematical problems. In solving representation problems, individuals who learn have different ways of thinking. This different way of learning depends on the cognitive processes of the individual. Cognitive style is an important aspect that plays a role in supporting mathematical thinking processes when solving mathematical problems in everyday life. Individuals with a field-independent cognitive style (FI) tend to be strong in reasoning and able to learn independently to increase their knowledge. This study aims to obtain a profile of the mathematical representation ability of prospective mathematics teachers based on field-independent cognitive style (FI). This research uses a descriptive qualitative method. The data obtained is based on the results of questionnaires, tests, and interviews. The results of the cognitive style test using the GEFT test were analyzed, and then three informants were selected in the high, medium, and low categories. The results showed that individuals with a high category FI cognitive style were not able to fully represent the meaning of mathematical problems. Individuals with a moderate category FI cognitive style have not been able to completely visualize mathematical problems. Individuals with a low category FI cognitive style have not been able to fully represent equations, expressions, and visual representations of mathematical problems. The lack of accuracy in checking the work results of the three informants is one aspect that is suspected to be the cause of incompleteness in solving mathematical representation problems. There needs to be individual strengthening on the aspect of accuracy in improving the representational abilities of prospective mathematics teachers.

Keywords: Mathematical Representation, Mathematics Teacher Candidate, Cognitive Field Independent (FI) Style.

1. INTRODUCTION

Solving mathematical problems in everyday life is needed by various students who study both elementary and higher education, and especially prospective mathematics teachers. The ability to represent mathematical data is one of the skills required of prospective mathematics teachers. Regarding the ability to solve mathematical problems, a prospective teacher's mathematical representation plays a role in increasing students' understanding of mathematical concepts and solving mathematical problems. Mathematical Representation, Mathematics Teacher Candidate, Cognitive Field Independent (FI) Style[1]. Representational ability relates to an individual's ability to transform mathematical problems into visual representations, expressions, mathematical equations, and verbal representations [2].

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The problems that are often encountered are problems in solving mathematics that contain artificial contexts and the use of mathematical concepts to solve real-world problems[1]. The results of previous research conducted by [3] show that based on the results of the analysis of the tests given, students are not able to complete the main indicators of mathematical representation abilities. Another review of research on gender representational abilities conducted by [4] reveals that individuals with the female gender can understand information and what is asked verbally and symbolically, bring plans visually in the form of geometric and mathematical formulas, carry out planning by drawing, manipulate mathematical models, and perform a symbolic recalculation at the subject's hindsight stage. Meanwhile, the mathematical representation of male subjects in expressing their ideas to solve geometric problems by understanding information and what is asked verbally, making plans in visual form in the form of images rather than mathematical formulas, carrying out plans by manipulating the mathematical models that have been made and looking back, doing the recalculation, and writing the conclusion.

Naturally, the representations that each student has are different, so the way students receive, process, and understand information is also different. The differences between each individual that determine how to receive, process, and understand the information are known as cognitive styles [5]. According to the Program for International Assessment of Adult Competencies (PIAAC) [6] counting behavior always involves situations in real contexts related to mathematical content that are processed through cognitive processes and represented in various ways. The context is related to real contexts such as individual, social, work, or further learning. Text or symbols, pictures of physical objects or objects, structured information, and dynamic applications are all examples of representation [7].

Thinking is a psychic activity that seeks a relationship between two or more objects. To put it another way, thinking is the mental or cognitive processing of information [8]. Individual cognitive processes differ from one another. Cognitive style influences an individual's perspective on the environment to receive, organize, and interpret information [9]. Cognitive style is a characteristic of students in learning that has to do with how they receive and manage information, their attitudes towards information, and habits related to their learning environment [10]. In the learning process, students will be found to have differences in their individual characteristics. Some individuals like discussions and like independent learning; these two characteristics possessed by these individuals have been grouped into field-dependent (FD) and field-independent (FI) cognitive styles [11]. Individuals with a field-independent cognitive style usually need help focusing attention on social content, need teaching how to use context to make sense of social information, tend to have self-defined goals and reinforcement, are not affected by criticism, can develop their structures in unstructured situations, and are usually better able to solve problems without explicit instructions and guidance [10]. Based on these problems, it indicates that reasoning needs to be a concern for prospective mathematics teachers' students and that there is a link between field-dependent cognitive style and mathematical representation ability. For this reason, it is necessary to examine more deeply how the process of applying for prospective mathematics teachers is based on field-independent cognitive styles.

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2. MATERIAL AND METHODS

2.1 Research Design

The design used in this study is a qualitative descriptive research design that describes the ability of mathematical representation based on the field's independent cognitive style. This study aims to obtain a profile of the ability of mathematical representation for prospective mathematics teachers in terms of students' field-independent cognitive style.

2.2 Sample and Data Collection

The data for this study were taken from students in semester VII of the mathematics education study program at Cenderawasih University, Jayapura, Indonesia. This study involved 12 people as research subjects. Three people were selected using a purposive sampling technique. Purposive sampling [12] is a sampling technique from data sources with certain considerations. The category of sample selection involves selecting a sample of three people from the field of independent cognitive style and the selection of three subjects based on the high, medium, and low categories based on the scores of the students' GEFT test results. Subjects for each category were coded to make it easier for researchers to carry out data analysis.

The cognitive style test questionnaire instrument that is given is a perception test in the form of pictures to determine the field-dependent cognitive style and the field-independent cognitive style, namely the Group Embedded Figure Test. The mathematical representation test is in the form of an essay in the linear programming course. Expert judgment validating the mathematical representation test instrument is declared feasible for use to obtain data according to its purpose. Then, the researcher conducted a limited trial of the research instrument. The results of the validity test showed that the mathematical representation ability questions are included in the valid and reliable categories.

2.3 Data analysis

Data analysis used a descriptive analysis method, namely analyzing the data by describing the data obtained to obtain mathematical representation skills based on FI and FD cognitive styles. Data collection was carried out using the cognitive style questionnaire data from the test results, and then three (three) cognitive style informants were selected as field independents (FI). Each category of field-independent cognitive style is divided into three categories: high, medium, and low.

The research subjects were given representational ability tests. Test result data from selected informants is used as a basis for conducting in-depth interviews. The data analysis step was carried out using test results and in-depth interviews to be grouped, reduced, presented, and hypothesized[12]. Test the credibility of the data using the triangulation test by comparing the data from the representation ability test and in-depth interviews.

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3. FINDINGS AND DISCUSSION

This study began with collecting data on students' cognitive styles using a questionnaire given to 12 informants. Table 1 below deals with the results of cognitive style tests.

Table 1: Informants Based on Cognitive Style Test Data

Tab.1

No	Informant	Score (S)	Category
1	NS	$S < 4$	Low FD
2	CN, YW	$4 \leq S < 7$	Moderate FD
3	NM, NA, AN, JP	$7 \leq S < 10$	High FD
4	NR, VK	$10 \leq S < 13$	Low FI
5	YI, RP	$13 \leq S < 16$	Moderate FI
6	WP	S16	High FI

Information:

FD: Field Dependents
FI: Field Independent

Each informant was taken from each category to obtain a profile of mathematical representation ability in terms of cognitive style. The three informants are VK, RP, and WP. Profiles of representational abilities were obtained based on test results, interviews with three informants, and documentation of the informants' worksheets. There are five indicators used to measure representational ability, namely: translating information; visual representation; representation of mathematical equations or expressions; determining solutions; and verbal representations. Interpreting information is characterized by the ability to select and interpret important information in a problem. The indicator of translating questions relates to the ability to change the problem into the form of the main information that is known and make it a question of the given problem. Indicator. Visual representation is related to an individual's ability to change known problems into visual forms (diagrams, graphs, and tables). The representation of mathematical equations and expressions is related to an individual's ability to change visually presented problems into the form of mathematical equations and expressions. Determining solutions is related to an individual's ability to determine solutions and steps that are appropriate for solving problems. Verbal representation is related to the individual's ability to write down each stage and sequence of problem-solving using words.

> Passenger aircraft have 48 seats; each first-class passenger may carry 60 kg of baggage, while the economy class is 20 kg. The aircraft is only allowed to carry 1440 kg of baggage. Main-class ticket prices are Rp. 2,750,000 for first class and Rp. 1,800,000 for economy class. So that revenue and class ticket sales when the plane is full achieve maximum revenue, what should airlines do?

Fig 1: Mathematical Representation Ability Thinking Test Questions

The results of the tests and interviews were then compared and analyzed to obtain a profile picture of the mathematical representation ability of prospective mathematics teachers. The results of tests and interviews with informants are described below.

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3.1 High FI Category Subjects (WP)

Informants in the High Field Independent (WP) category start solving mathematical problems by determining variables by translating questions or changing mathematical problems into the form of equations and mathematical expressions. WP supposes that x is the number of first-class passengers and y is the number of economy-class passengers. WP hasn't worked out a mathematical model of the problem yet. WP writes that constructing the constraint function and objective function from a mathematical expression is the most important step in solving the problem after constructing a visual or tabular representation of the mathematical problem.

Further informants WP attempt to determine the intersection point for each equation, that is for $60x + 20y \leq 1440$ (1), by simplifying the equation to $3x + y \leq 72$ so that the x and y values are (0.72) and (24.0). And when we look for the critical points of the equation $x + y \leq 48$ (2), we get (0.48) and (48.0).

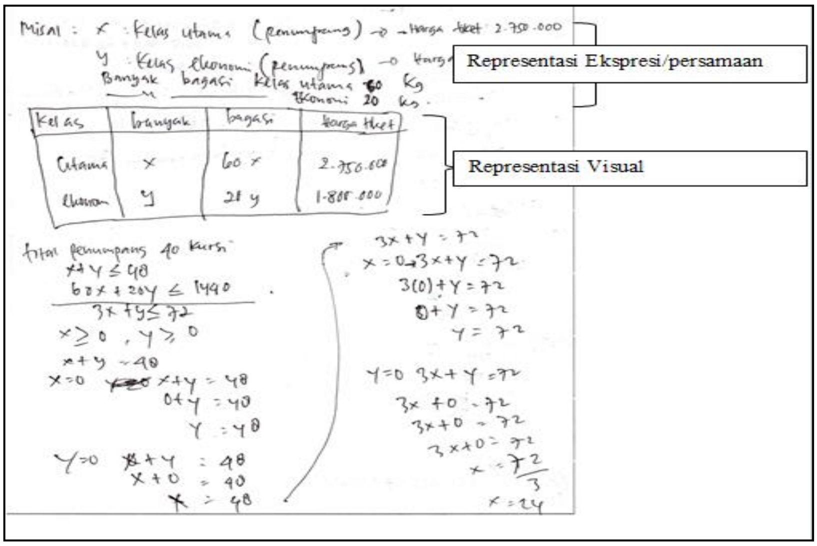

Fig 2: WP's answers to the linear program questions

Furthermore, the WP informant draws a graph of the intersection points that have been found in equations (1) and (2). Then WP determines the maximum solution by finding the z value of each extreme point. Furthermore, the WP informant determines the intersection point between equation (1) and equation (2) so that the critical point is 12.36, and then looks for the z value for that critical point. From the results of the work, WP can then determine the value of x, which is 12, and the value of y, which is 36. But in the final result, WP has not determined the maximum z value sought.

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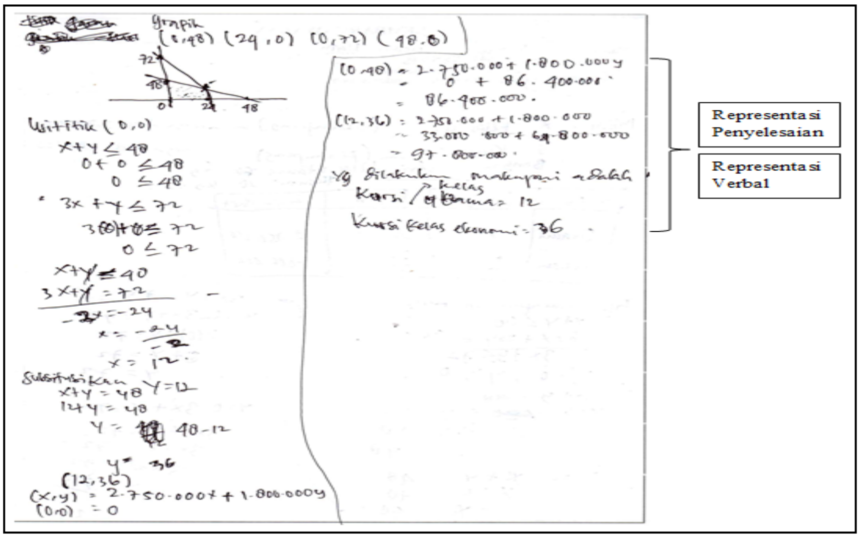

Fig 3: Continuation of WP's Answers to the Linear Program Questions

The following is an excerpt from an interview with WP.

Q: What problem is this related to?

WP: This is a linear programming problem.

Q: What do you know and what are you asking?

WP: The known number of seats and baggage, for which the maximum z value is asked.

Q: Why not jot down what is known and what is being asked?

WP: I don't write it again because I already understand it.

Q: From the results of your work, why is there no maximum z value and also no conclusions from your work?

WP: I was confused at last, sir, and I also forgot to write down the conclusion.

The results of the researcher's interview with the WP informant are not much different from the results of the written test work from the WP. It is known that even though there are missed completion steps and the complete sequence is not sequential, the WP informant can solve known problems. The informant did not write down the representation of the meaning of the questions, but the WP understood the problem to be searched for; the WP could also compile known problems into the form of a visual representation (problem tables and graphs of completion) although incomplete; the WP could compile mathematical equations or expressions of known problems; the WP can determine steps to solve the problem even though there are parts that are omitted; and the JP can compile verbal representations of known problems even though there are parts that are incomplete and the WP does not write a conclusion.

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3.2 Moderate FI Category Subjects (RP)

Informants with the Moderate Field Independent (RP) category started solving mathematical problems by writing down what was known and asked; the RP informants did not write down the variable form of the problem, the RP informants did not write down the known information in graphical or tabular form, and the RP informants also did not arrange constraint functions and the objective function of the known information. The RP informant compiled the final settlement of the information known by using the assumption that if he only sold all 48 seats main class tickets, namely by dividing the maximum load on the aircraft baggage, which was 1440 kg, by the maximum amount of baggage for each main class passenger, namely 60 kg, so that 24 seats were multiplied by the maximum price for a main class ticket, which is IDR 2,750,000.00, the maximum value obtained is IDR 66,000,000.00. With the same assumption, the maximum number of seats obtained is 72 because the maximum number of seats provided by the airline is determined to be 48 as the maximum ticket sales, so the maximum profit is IDR 81,400,000.00. The RP informant then used other assumptions to find the maximum value by halving the maximum number of seats previously obtained, namely dividing by two to obtain 12 main seats and 32 economy seats, so the maximum profit is IDR 97,800,000. The RP informant then summarizes the results of his work. The RP informant then used other assumptions to find the maximum value by halving the maximum number of seats previously obtained, namely dividing by two to obtain 12 main seats and 32 economy seats, so the maximum profit is IDR 97,800,000. The RP informant then summarizes the results of his work. The RP informant then used other assumptions to find the maximum value by halving the maximum number of seats previously obtained, namely dividing by two to obtain 12 main seats and 32 economy seats, so the maximum profit is IDR 97,800,000. The RP informant then draws conclusions from the results of his work…

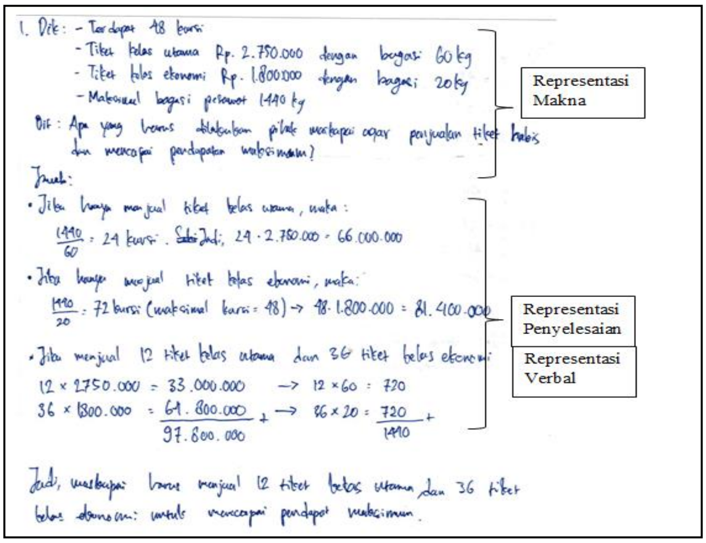

Fig 3: RP's Answers to Linear Programming Questions

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The following is an excerpt from an interview with RP.

Q: What problem is this related to?

RP: As far as I know, it's a linear programming problem, sir, looking for the maximum value.

Q: Are there steps to solving this problem?

RP: As far as I know, there are several steps for solving it, but I forgot, sir.

Q: I see from your work that there is a solution; how do you implement it?

RP: I'm using the assumption, sir, that after seeing the problem I started to think about how to find a solution.

Q: What three assumptions did you make? I see them as a trial and error.

RP: That's right, sir. I actually tried. So first, I try to divide the maximum amount of baggage by the maximum baggage per passenger. Then, from the results of the division, I multiply it by the ticket price, so I get the maximum value of IDR 97,800,000.00.

Q: Why are there no tables or graphs of this problem? Isn't this kind of problem easier to solve if we can translate it?

RP: Absolutely true, sir. It's just because I forgot how to rearrange it, so I chose not to write it down, sir.

The findings of interviews with RP informants are not significantly different from the findings of RP's written test work. It was found that the RP understood the intent of the questions, so they could write them down on the worksheet. The RP informant could not compile steps for completion, that is, he could not determine the constraint function and the objective function, look for critical points, and determine the maximum value of each critical point. The informant cannot determine the solution to the problem based on the completion steps, but the RP can determine the final solution based on assumptions and determine the final solution that is right and follows what is desired from the problem. RP informants can arrange settlement solutions using words that can be understood.

3.3 Low FI Category Subjects (VK)

Informants in the Low Field Independent (VK) category started solving mathematical problems by translating the questions to find out what was known and what was being asked, but what was known in the questions was incorrect because this information should have been part of a mathematical equation or expression. The work results of the VK informants are not arranged in the order of their completion. VK informants begin by determining the critical points of the equation $x + y \leq 48$, which are 0.48 and 48.0. Furthermore, VK determines the critical points of the equation $60x + 20y \leq 1440$, namely (0.72) and (24.0). From equations (1) and (2), the VK informant determines the point of intersection of the two equations, namely 12.36. Of all the critical points that have been obtained, VK then looks for the maximum value of each critical point to obtain a larger maximum value, such as the maximum value obtained when the critical point (12.36) obtains a maximum Z value of IDR 97,800,000.00. VK informants can

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write conclusions using words that can be understood.

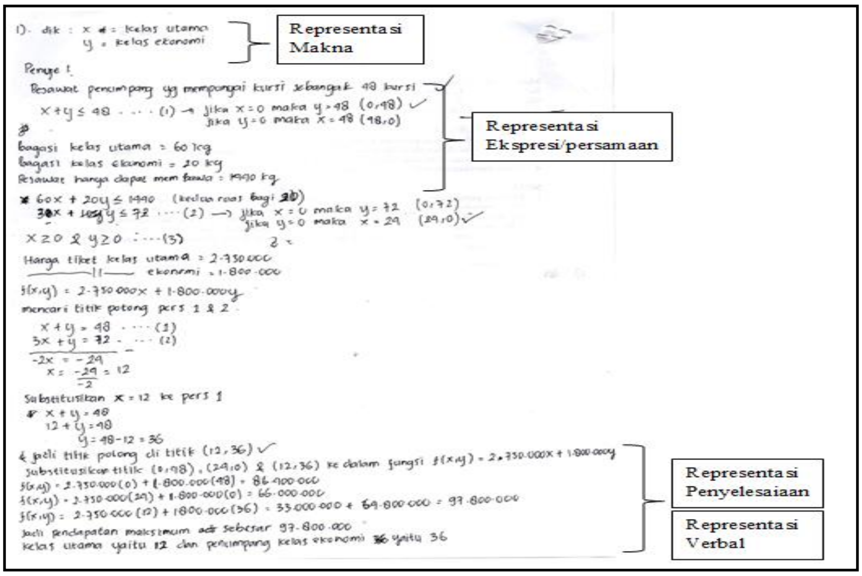

Figure 4: VK's answers to linear programming questions

The following is an excerpt from an interview with JP.

Q: What problem is this related to?

VK: This is a matter of maximizing costs; material is a matter of linear programming, sir.

From your job, it is written that way, but why did you write it that way?

VK: I misunderstood, sir, because I thought what was being asked was an example of direct x and y.

Q: Why are there no tables or graphs of your work?

VK: I didn't write it down because I already understood the meaning of the question, sir.

Q: For problems like this, is there a sequence of work?

VK: There are about six steps, sir, but I forgot the steps, so I did it in an irregular manner, sir.

Q: Thank you.

The results of interviews with VK informants are not much different from the results of the written test work from VK. It was found that VK understood the meaning of the questions but was unable to translate the meaning into what was known and what was being asked. VK informants could not compile steps for solving that, which is determining the constraint function, the objective function. VK informants can determine the completion steps to look for critical points, but the sequence is not regular. The VK informant can determine the maximum score based on known critical points, so the final solution from the VK informant is following the information provided.

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Based on the description of the written test results and interview results of the three informants with high, medium, and low field-independent cognitive style (FI), it was found that the higher the self-independent cognitive style (FI), the more complete the process of mathematical representation of the individual, and vice versa. These results are thought to be influenced by the informant's ability to understand the questions posed to the informant and the prior knowledge of the informant.

When informants can use the required material, it allows individuals to easily model mathematical problems into appropriate forms. The informant's WP and VK were not able to rearrange the mathematical problems into meaning (what is known and what is asked). Only WP informants can represent the intended information from mathematical problems in visual form (graphs and tables). WP and VK informants can solve mathematical problems in the form of mathematical expressions or equations, even though they are not completely complete. WP and VK informants solve mathematical problems by following the completion steps that correspond to the question instructions, while RP informants are more likely to use their reasoning abilities to find solutions. RP and VK informants can verbally represent the results of their work so that the steps in their completion can be easily understood. This finding is consistent with other studies in which determining the material studied is very easy in solving the next problem[13] and previous information processes affect reasoning and problem-solving processes [14]. The use of previously studied schemes facilitates individuals' ability to solve mathematical problems, as does the process of drawing conclusions [15] and using structural similarities as determinants in solving other mathematical problems [16].

Individual cognitive processes are related to the ability to solve mathematical problems, especially the process of mathematical representation. Differences in individual cognitive styles, especially field-independent (FI) cognitive styles, affect individual work, especially in the process of solving mathematical representation problems. Individual teacher candidates with a high field-independent (FI) cognitive style can fulfill all stages of representation, although not completely. Individual prospective teachers with a moderate field-independent (FI) cognitive style are only able to fulfill four of the stages of mathematical representation, while individual teacher candidates with a field-independent (FI) cognitive style are only able to meet the three stages of the indicator ability of mathematical representation.

The process of representing prospective mathematics teachers and students is thought to be influenced by the process of checking back on the results of work that has been done. The incomplete results of the work of moderate and low-level independent field informants (FI) were suspected because they did not carefully re-examine the results of the work they had done. The review process is carried out in a structured and systematic manner to provide certainty on the results of the work that has been done[17].

This research is limited to the thinking process of the mathematical representation of prospective teacher students based on field-independent cognitive style (FI). Other possible factors can influence the thinking process behind mathematical representations. More in-depth research on representational thinking processes needs to be studied more deeply.

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4. CONCLUSION

Cognitive style, specifically the field-independent cognitive style (FI), influences the mathematical representation of prospective mathematics teacher students. The higher the field-independent cognitive style (FI), the more complete the process of mathematical representation. The main indicator of mathematical representation is the representation of meaning or the ability to change mathematical problems (story problems) into meaning (what is known and asked). With the individual's ability to fulfill this indicator, the next stage can be easier to solve. This is because not all mathematical problems can be solved with just one reading of the problem. After all, stronger reasoning is needed. Long knowledge, strong reasoning ability, proper use of schemes.

The practical implication of this research is to provide knowledge for prospective mathematics teacher students to be able to improve individual abilities, especially field-independent (FI) cognitive styles, so that they can support their representation abilities. Prospective math teachers must also be able to optimize their experience, comprehend the material, and reason in order to improve their representational abilities.

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