The students’ mathematical critical thinking process reviewed from the cognitive style

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Abstract. The research aims to reveal and describe students' mathematical critical thinking process regarding the cognitive styles field dependent (FD) and field independent (FI). This study uses qualitative methods with the subject of two eighth grade junior high school students in Tasikmalaya. Selection of research subjects using purposive sampling based on the results of cognitive style tests. Data collection techniques through the Group Embedded Figures Test (GEFT), mathematical critical thinking tests, and interviews. Mathematical critical thinking process refers to indicators: giving simple explanations, building basic skills, making further explanations, determining the right strategies and tactics to solve problems and make conclusions.

1. Introduction
The success of students in learning one of them is influenced by their ability to think. Problems related to daily life and things experienced by students can slowly grow the habit of thinking and imagining well. Critical thinking skills related to one's thinking process in solving problems in a reflective and logical thinking by considering the reasons that support to obtain a trusted or made decision [1-4].

Thinking is an act of manipulating and transforming information in one's memory. Thinking is an activity to form concepts, reason, think critically, make decisions, think creatively, and solve problems [5]. Whereas critical thinking is a person's intellectual process to understand problems skillfully, interpret, apply, analyze, synthesize, and evaluate information obtained through his observations and reasoning to obtain valid and reliable conclusions. The ability to evaluate and convey reasons is an essential aspect of interacting with others. It shows that critical thinking is considered an essential factor in the world of education and is needed to gain success in the academic field and success in life [6, 7]. Critical thinking is a skill always to be careful about making every decision in a problem — these skills as one of the main goals and aspirations in the field of education [8]. As needed skills, critical thinking includes cognitive skills that have complex concepts that affect the way teachers in presenting educational concepts to students [9].

One factor that must be considered in developing students' critical thinking skills is cognitive style. Cognitive style has an important role compared to other factors [10]. Also, if compared with other variables in the affective or physiological domain, cognitive style is the most relevant to variables related to academic achievement [11]. Cognitive style reflects the characteristics of different students, such as interest, attitude, motivation and thinking ability. As one of the important
factors of cognitive development, critical thinking is determined by the manipulation and interaction of children with the environment, social interaction also has an important role in developing children's thinking, so that eventually the child can think more critically and logically [12].

Cognitive style can be interpreted as a characteristic or habits of students which is a style in distinguishing and responding to phenomena that occur, for example how an individual's style of thinking, learning, remembering, solving problems, and making decisions [12-14]. Witkin classifies cognitive style into two, namely cognitive style FD and FI [15]. To find out the cognitive style types of FD and FI, can use a measuring instrument in the form of a test of GEFT (Group Embedded Figures Test). Students who have an cognitive style FD tend to see the overall pattern and the difficulty in understanding and separating more complex patterns from the manipulation of simple parts that are hidden, while students who have a cognitive style FI, are not affected by these manipulations so that they can see hidden parts on more complicated patterns [12, 13, 16].

This study aims to determine the students' mathematical critical thinking process on the content of the prism and pyramid subject matter regarding the cognitive styles FD and FI.

2. Method
This research is a qualitative descriptive study with the aim of expressing and describing students' mathematical critical thinking process regarding the cognitive styles FD and FI.

2.1. Participants
The study was conducted on eighth-grade students of the junior high school in Tasikmalaya with two subjects. The research subjects were selected based on the results of the GEFT test in one class through a purposive sampling technique, namely one student who had cognitive style FD and one student who had cognitive style FI. Moreover, as well as teacher consideration, that is seen from the students' mathematical values, students' activeness in mathematics learning, cooperative and communicative in expressing ideas or opinions, both in writing and verbally.

2.2. Data collection
Determination of field-dependent cognitive style using GEFT test developed by Witkin, Oltman, Raskin & Karp [17]. The GEFT test is a standard test consisting of 18 complex images using score classification criteria from 0-18. Subjects who get a score (0-11) are called FD, and the subject which gets a score (12-18) is called FI [18, 19].

Data collection is done through written tests and interviews. Tests and interviews are conducted twice on different days to get valid subject data. If there is consistency in the results of the first test and the results of the second test, then the data obtained is valid data.

2.3. Data analysis
Data analysis techniques are carried out by: (1) grouping data based on 5 indicators: (a) providing simple explanations, (b) building basic skills, (c) making further explanations, (d) determining the right strategies and tactics to solve problems, and (e) make conclusions; (2) presenting data in the form of narrative text; and (3) conclude students' mathematical critical thinking process in terms of cognitive style.

3. Results and Discussion
Results of the first test and interview data were analyzed and triangulated by analyzing the results of the test data and the second interview to obtain valid data. Then the valid data is used to determine students' mathematical critical thinking process. The valid data from both research subjects is described in Table 1.
Table 1. Research subject data

| Indicator (I)                                      | Field Dependent (FD)                                    | Field Independent (FI)                                    |
|---------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|
| I1                                                | unable to provide a simple explanation                  | able to provide a simple explanation                      |
| I2                                                | able to build basic skills                              | able to build basic skills                                |
| I3                                                | unable to make further explanations                     | able to make further explanations                         |
| I4                                                | unable to determine the strategies and tactics that will be used | able to determine the strategies and tactics that will be used |
| I5                                                | unable to make conclusions                             | able to make conclusions                                  |

Then, we analyzed the mathematical critical thinking process of students synchronized with the characteristics of the mathematical thinking process in providing simple explanations, building basic skills, making further explanations, determining the right strategies and tactics to solve problems, and making conclusions.

3.1. Mathematical Critical Thinking Process Subject FD (S1)

In the indicator giving a simple explanation, the S1 does not understand the problem and is less thorough. Solving questions should have two possibilities, namely cubic rectangular prism and beam-shaped rectangular prism. Because of the lack of thorough understanding of the problem, S1 only draws one possibility, namely a rectangular shaped cubic prism and has a pyramid shaped lid. It is in line with Juniarti's opinion that students field dependent has not been able to present the problems in the problem correctly [20]. Another thing indicated by the S1 is that it does not understand the information contained in the problem, namely not writing down what is known and asking the question. Riding & Cheema states that individuals who have a cognitive style field dependent tend to find it difficult to separate information received and not selective in absorbing information [21].

Judging from the results of the interview, S1 can answer the researchers' questions, but the S1 is not able to identify the criteria to consider possible answers. So that based on the results of the tests of mathematical critical thinking skills and interviews, it can be said that S1 does not meet the indicators to give a simple explanation.

Although S1 does not write down the information contained in the problem, S1 can use information from the problem and can use its fundamental knowledge for a problem. It is indicated by the S1 so that it can determine the concept or idea used in solving the problem in the form of prism volume formula, pyramid volume, prism surface area, and surface area of the pyramid. In solving the problem, the S1 can make an extended example, that is, from the draw he draws. The interview results show that S1 can explain the formulas that must be used to solve problems in the problem. So, based on the results of tests of critical thinking skills and interviews, it can be said that S1 meets the indicators of building basic skills.

In the indicator making a further explanation, the S1 does not explain the problem given that the ratio of the surface area of the two built spaces is not the same as the volume comparison. S1 performs calculations to prove what is being asked about the problem, but the calculation results are not correct. It is because S1 is not careful in solving problems.

The results of the interview show that S1 can mention the ratio of the surface area of the two spaces to the same space as the volume ratio. Judging from the results of the interview, S1 is not sure and incorrect with the answers given. So that it can be said that the S1 is not able to provide further explanation.

In the strategy and tactics indicator, the S1 is less able to determine the steps that must be taken to solve problems in the problem. To prove it, the first step taken by S1 is to calculate the surface area of the rectangular prism in the form of cubes and the surface area of the pyramid. After knowing the size of the surface area, they are compared. Then look for the volume of the prism and pyramid, then compare it. After the ratio of volume and surface area is known, S1 does not compare whether the ratio of volume and surface area of the two buildings is the same or not, even though this step is one
of the essential steps that must be done to answer the question on the problem. It is seen that the S1 does not use all the information in the problem in the completion step. It shows that the S1 cannot identify the relationship between the information available on the problem and the knowledge and concepts that are owned as a strategy to solve the problem.

S1 is not able to determine the conditions that must be sought before solving the problem, namely looking for the height of the side of the pyramid. S1 believes that the height of the upright side of the pyramid is equal to the height of the pyramid. According to Desmita, individuals with FD cognitive styles tend to accept the pattern or context as a whole; they have difficulty focusing on one aspect of one situation. Moreover, the solution is also incomplete, S1 only resolves the problem when the rectangular prism is just cubic [12]. Based on the results of the tests of mathematical critical thinking and interviews, it can be said that the S1 is less able to determine and consider the actions that must be done in solving problems, so it can be said that S1 does not meet the indicators determining strategy and tactics.

S1 is not able to solve the problem completely, from the results of the answer it can be seen that S1 cannot write the final solution asked on the question so that it is unable to conclude according to the facts. The interview results indicate that S1 is doubtful and wrong when answering the researcher's question. S1 assumed that the ratio of surface area and volume of the pyramid was the same. This error occurs because the S1 is not thorough in solving the problem, the S1 is unable to determine the conditions that must be sought before calculating the surface area of the pyramid. Based on the results of the tests of mathematical critical thinking and interviews, it can be said that the S1 is not able to conclude the problems that exist in the problem. So, it can be said that S1 does not meet the indicators making conclusions.

From the discussion that has been presented also reflects that S1 has the cognitive style dependent field. S1 is less able to determine and consider an action that must be done in solving problems and the steps used are also not sorted. S1 is easily affected by the context of the given problem, namely when it is stated that the height of the pyramid is equal to the height of the prism. It should be calculated in advance of the height of the pyramid from the steep side of the pyramid using Pythagoras theorem then substituted the high value obtained into the surface area formula pyramid, but S1 is not able to calculate the height of the vertical side of the pyramid. S1 assumes that the height of the side of the pyramid is equal to the height of the prism. S1 makes a mistake when calculating, this is because the S1 is careless in calculating and less accurate. Also, the undergraduate program is also less independent, when an interview is conducted, the S1 asks the researcher about other constructs that might be formed.

3.2. Mathematical Critical Thinking Process Subject FI (S2)

In the indicator giving a simple explanation, the S2 can understand the information contained in the problem. S2 can draw three possibilities of building a rectangular prism-shaped space that has a clear and correct pyramid shaped lid. These three possibilities are beam-shaped rectangular prisms and cubic rectangular prisms. Riding & Cheema mentions that individuals with cognitive style fields independent does not experience difficulties in separating information and is more selective in absorbing information received [21]. Another thing that shows that the S2 understands the problem, namely being able to write complete and correctly what is known and asked about the question.

On the indicator of building basic skills, the S2 can use the information obtained and use his fundamental knowledge for a problem. It is shown in determining the concept or idea used to solve the problem in the form of prism volume formula, pyramid volume, the surface area of prism and pyramid entirely and correctly. To simplify the completion, the S2 is also able to make the length, width, and height of the building presented in the problem. When calculating the volume and surface area of the prism, the S2 can determine the formula that must be used to facilitate the calculation process, namely using the formula of the volume and surface area of the cube and the beam.

In the indicator making a further explanation, the S2 was able to explain the problem that the ratio of the second surface area to the building space is not the same as the ratio of volume. S2 showed
this by explaining that in the square-shaped rectangular prism, the ratio of the surface area of the two built spaces is not the same as the volume ratio, because the prism and pyramid volume ratio is 3 : 1, while the ratio of surface area is 4 : (a² + ab).

S2 also explained that in the rectangular prism in the form of cubes, the ratio of the surface area of the two spaces is not the same as the volume ratio, because the volume ratio of prism and pyramid is 3 : 1, while the ratio of surface area is 6 : (1 + √5). Each step of the completion also evidenced the explanation presented by S2, the results of the interview also showed that the S2 was able to explain the ratio of the volume and surface area of the prism and pyramid were not the same and was able to explain why the results obtained were not the same. It is also the same as the results of Rifqiyyana's research [22] which shows that students who have cognitive styles are independent field able to act by providing further explanation of the problems given.

In the indicators of strategy and tactics, the S2 can work on the questions coherently and correctly and can explain well the problem-solving steps that have been found during the interview. In the S2 strategy stage, it is also able to determine the conditions to be sought before solving the problem, namely before calculating the surface area of the pyramid, S2 calculates the height from the vertical side of the pyramid first using Pythagoras theorem then substitutes the high value obtained into the pyramid surface area formula. Abidin explained that students who have cognitive styles independent field tend to be more analytical, more accessible to solve or solve problems and tend to be structured [13]. S2 is not affected by the manipulation of deceptive elements and can determine simple parts that are hidden in more complex parts, namely can find the height of the pyramid before calculating its surface area, so it can be said that the S2 can find the right steps as a problem-solving strategy in a systematic and correct manner.

To solve the problem in the given problem, S2 divides the solution into two, namely when the rectangular prism is in the form of a block and is cube-shaped. The first step S2 calculates the volume of the square-shaped rectangular prism and the volume of the pyramid after it is known that the volume of the two is then compared. Moreover, calculating the surface area of the pyramid and prism, then compare it. After the ratio of volume and surface area is known, the next step is done by S2, which is comparing whether the ratio of volume and surface area of the two buildings is the same or not. However, S2 made a mistake when calculating the height of the vertical side of the pyramid using Pythagoras theorem. Therefore, the results of the surface area of the pyramid at the time of the beam-shaped prism are also less precise. When the rectangular prism is in the form of a cube, the completion steps used by S2 are also the same, but do not make mistakes in the calculation process. Although S2 made a mistake when calculating the height of the vertical side of the pyramid, the S2 was able to determine and consider an action that must be done in solving the problem.

In the indicator making conclusions, S2 can write conclusions from the problems in the problem, S2 explains that when the rectangular prism is in the form of a beam, the ratio of the second surface area of the building space is not the same as the volume ratio. So, it can be said that the S2 meets the indicators making conclusions.

Subjects with cognitive style are independent field able to find the final solution so that they can conclude by the facts on the problem [20]. The cognitive style possessed by the S2 is also seen from the attitude shown and the results of the test answers to the mathematical critical thinking process. When completing a problem, S2 is more individualistic and confident with the answer. It was indicated by the attitude of the S2 when working on the test process of critical mathematical thinking, looked confident and able to solve the problem correctly. Judging from the results of the test answers indicate that the S2 can determine and consider an action that must be done in solving the problem and the steps used are also sorted and clear. S2 can calculate the height from the vertical side of the pyramid by using Pythagoras theorem then substitute the high value obtained into the formula of the surface area of the pyramid. It shows that the analytical S2 in working on the problem so that it can solve the problem.
4. Conclusion
This study concludes that students who have a cognitive field dependent style are: (1) unable to identify criteria to consider possible answers; (2) can use initial knowledge for a problem; (3) cannot provide an explanation that the comparison of the surface area of both the building space is not the same as the ratio of its volume; (4) unable to determine the conditions that must be sought first before solving the problem, namely looking for the height of the pyramid upright; and cannot write the final solution that is asked on the question so that it is unable to draw conclusions according to the facts. Also, students are less able to determine and consider an action that must be done in completing the questions and steps used are not sorted out, easily affected by the context, careless in calculating, inaccurate understanding the problem in a simple, less independent and not confident with the answer. While students who have a field-independent cognitive style, namely: (1) can mention the information that is known in the problem, (2) formulate and answer questions, and identify criteria to consider possible answers; (3) can use initial knowledge for a problem; (4) can provide an explanation that the comparison of the surface area of both the building space is not the same as the ratio of its volume; (5) can determine and consider an action that must be done in solving the problem; able to determine the conditions that must be sought first before solving the problem, namely looking for the height of the pyramid upright; and can write the final solution asked so that it can draw conclusions in accordance with the facts. Also, students are more individualistic and confident in the answer, able to determine and consider an action that must be done in solving the problem and the steps used are also more ordered and precise, more analytical in working on the problem so that they can solve the problems presented in the questions.

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