Mathematical critical thinking ability of students grade VII in solving one variable linear equation questions based on their cognitive style

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Abstract To face the industrial revolution 4.0, the abilities that should be possessed by students are high-level thinking skills that include mathematical critical thinking skills. Critical thinking is the ability to analyze information obtained based on facts in order to make reasonable conclusions. This is a qualitative descriptive study that aimed to determine and illustrate the critical thinking skill of students with filed dependent (FD) and filed independent (FI) cognitive in solving a single variable linear equation problem. Two students selected based on the GEF test acted as the subjects of this study. One of them had FD cognitive while the other had the FI cognitive. The instruments used in this study were (1) mathematical critical thinking tests, (2) cognitive style tests in the form of GEF, and (3) interviews. Data analysis techniques in this study consisted of (1) data reduction, (2) data presentation, (3) verification and conclusion. The indicators of students’ mathematical critical thinking skill included (1) reason and (2) clarity. It was found that (1) student with filed dependent style on reason indicator needed to get used to making an argument or reason, while for clarity indicators, FD subject could change statements into mathematical symbols clearly and precisely. (2) Students with cognitive style FI, chose and gave reasons and drew conclusions correctly, changed statements into mathematical symbols clearly and precisely.

Keywords: Mathematical critical thinking skills, cognitive styles, one variable linear equations

1. Introduction
In the era of industrial revolution 4.0, Indonesia needs human resources (HR) with good quality to support the progress of the nation and the State. To face the industrial revolution 4.0, citizens should have skills of information, learning and innovation, life, and communication. The content of 21st-century learning has to always adapt to any changes might happen in the industrial era 4.0 [1]. The shift of 21st-century learning paradigm and competency framework are the foundation in developing the curriculum 2013. This curriculum is presented to prepare the generations to be ready to face the future. Therefore, the curriculum is designed to anticipate future developments [2].

Cognitive style is one of the learning variables that need to be considered in designing learning. It is a way for students to receive and process information. According to [3], cognitive style relates to the way of a person processing information and using strategies in responding to a task. Similarly, [4] stated that cognitive style is an individual character in the use of cognitive functions (thinking, remembering, solving problems, making decisions, organizing and processing information). In developing the critical thinking, everyone has their ways are preferred in preparing what is seen, remembered, and thought.
The differences in each are how to prepare, and process information and experiences are known as a cognitive style [5].

Nowadays, the abilities that should be possessed by students are high-level thinking skills that include mathematical critical thinking skills. Students who have critical thinking skills will become a high-quality young generation. [6] argues that in the era of globalization, critical thinking skill is an indispensable ability so that students are able to deal with changing conditions or challenges in life that are always developing. [7] states that the top three levels of learning goals by Taxonomy Bloom (analysis, synthesis, and evaluation) are often expressed as critical thinking skills. Critical thinking is the ability to analyze information obtained based on facts in order to make reasonable conclusions. According [8], one who possesses a good critical thinking has a particular high level of intellectual functions, such as the ability to analyze, to deduct conclusions and to assess them.

Educators often identify a number of students with low mathematical thinking skills. This can be seen when students try to understand various mathematical concepts, analyze, correct the concepts through mathematical deduction steps, and form valid conclusions [9].

Therefore, the purposes of this study were to (1) determine the students' mathematical critical thinking skills in solving linear equation problems one variable in terms of students' cognitive field dependent style and (2) understanding students' critical thinking skills in solving a single variable linear equation problem reviewed from cognitive field independent students.

2. Method

This is a qualitative research. The instruments used in this study were (1) mathematical critical thinking tests, (2) cognitive style tests in the form of GEFT, and (3) interview guidelines. The critical thinking indicators analyzed in this study were reason and clarity. The former one was to change statements into mathematical symbols clearly and precisely, while the latter one referred to the ability to choose and make an argument (reason) correctly, logically, and relevantly.

Data analysis techniques in this study consisted of (1) data reduction, (2) presentation, (3) verification and conclusion. Subjects in this study were students in the seventh grade of junior high school, who were initially given a cognitive style test to determine their cognitive style whether Field Dependent (FD) or Independent Field (FI). Furthermore, the two subjects were given mathematical critical thinking tests and invited for an in-depth interview. The scores obtained were between 0-18. In 1971 Witkin developed the criteria of cognitive style. Following were the criteria by Witkin in [10]:

| Cognitive Style          | Score     |
|-------------------------|-----------|
| Field dependent (FD)    | 0 ≤ x ≤ 11 |
| Field independent (FI)  | 12 ≤ x ≤ 18 |

The selected research subjects are as follows:

| Research Subject | Students’ Code | Category     |
|------------------|---------------|--------------|
| FD-12            |               | Field Dependent |
| FI-07            |               | Field Independent |

3. Result and Discussion

Many factors influence individuals in solving mathematical problems e.g. cognitive style. Cognitive style is one of the learning variables that reflects student characteristics, in addition to other characteristics such as motivation, interests, and attitudes. Individuals differ in terms of how they detect experimental tasks. However, this variation does not reflect the level of intelligence or special ability.
patterns [4]. Therefore, researchers examined students' mathematical critical thinking skills based on their cognitive style. The cognitive styles discussed here are the FD and FI.

The number of subjects in this study was two. One of them was the one with the cognitive style of FD while another one was the one with FI. They were selected based on the GEFT cognitive style test distributed to 30 grade VII students.

Mathematical critical thinking ability test was to measure the indicators of reason including the ability to choose and make excuses correctly, logically and accurately. Here, it was found that the mathematical critical thinking abilities of FI-07 and FD-12 students were different. The following are questions that measured the mathematical critical thinking skills on reason indicators.

“Indah’s house is built on land with a size of not more than 195 m² as seen in the sketch below. Determine the value of \( x \) that allows Indah to get the widest land. Give reasons for your answer!”

![Figure 1. Indah’s House Sketch](image)

Following are the answers of FI-07 subjects on indicators of reason:

![Figure 2. Answer of FI-07 subject on reason indicator](image)

The figure below is an example of an answer for students who had a cognitive style FD on the reason indicator.

![Figure 3. Answer of FD-12 subject on reason indicator](image)
Based on Figures 2 and 3 above and interviews conducted to subjects FI-07 and FD-12, there were slight differences in their answers. In this case, the FI-07 subject stated that she chose the number 8 because it was the maximum settlement set, while the FD-12 subject did not give any reason but showed the right answer. According to the FD-12 subject, the steps that were carried out were the reason. In this indicator, besides expected to have the right answers, students were also required to choose and provide reasons correctly, logically and accurately which could support the answer. Fisher said that critical thinking is a skillful and active interpretation and assessment of observations and communication, of information and argumentation [8].

Mathematical critical thinking skills test to measure indicators of clarity assessed the ability of students to change statements into mathematical symbols clearly and precisely. The following are questions that measured mathematical critical thinking skills on clarity indicators:

“There are three consecutive even numbers. Sum of the third number is 66. If the first number is \( p \), specify the other three numbers and explain your calculations!”

Here is the answer to the subject FI-07:

![Figure 4. Answers of subject FI-07 on the clarity indicator](image)

The following picture is the answer to the FD-12 subject to the clarity indicator.

![Figure 5. Answer of subject FD-12 on the clarity indicator](image)

Based on Figures 4 and 5 above, we could identify that those subjects changed statements into mathematical symbols clearly and precisely. Although there is a slight inconsistency in the algebraic operation. However, result of interviews conducted to subjects, they stated that did not divided the both sides by 3 because they have understood, if \( 3p = 60 \), \( p = \frac{60}{3} \). That means both sides are divided by 3. Therefore, the inconsistency does not reflect that both subjects have errors. Result of interview
conducted to subject FI-07 found that she changed statements into mathematical symbols clearly and precisely because she understands a even number is multiple of two. So, the consecutive even numbers are the previous term is added by two. Therefore, she obtained three consecutive even number whose the sum is equal 66. The consecutive number were $p + (p + 2) + [(P + 2) + 2] = p + (p + 2) + (p + 4) = 66$.

Result of interview conducted to subject FD-12 found that he changed statements into mathematical symbols clearly and precisely through trial and error, which is then poured into mathematical symbols. He tried that three consecutive even number whose the sum is equal 66 was $20 + 22 + 24$. Therefore, he obtained that $20 + 22 + 24 = p + p + 2 + p + 4 = 66$.

In this indicator, students were expected to provide clarity on their answers so that the readers can easily understand it. This clarity indicator requires a mathematical reasoning. According [11], mathematical reasoning as a part of mathematical thinking that involves forming generalizations and drawing valid conclusions about idea and how they are related. When reading the question above, the answer can be guessed immediately by student, “three consecutive even number whose the sum is equal 66 were 20, 22, and 24”, however, what is needed here is the students’ ability to express problem and their solution into mathematical symbol. Based on the answers represented above, both subjects FI-07 and FD-12 direct their thoughts to answer the problem given correctly. Both had the same thinking pattern.

Based on the answers above, it can be seen that FD students tend to prefer humanitarian and fantasy material because their creativity could be developed through their imagination [12]. Although the mathematical critical thinking skill of FD students for the indicators of reason was still lower than that of the FI students, it does not mean that students had less intelligent. Indeed, it was affected by the characteristics of their cognitive style which tended to accept the pattern as a whole and the difficulty in carrying out the analysis [4].

4. Conclusion
Based on the discussion above, it can be concluded that (1) students with the cognitive style of FD or in this case the FD-12 subject needed to get used to making an argument or reason. This is because, in critical thinking, someone is not only required to be able to answer correctly but should also able to explain the reason for choosing the answer. As for the clarity indicator, the FD-12 subject changed the statement into mathematical symbols clearly and precisely. (2) students with FI cognitive style in this case FI-07 subjects chose, made reason, and drew conclusions from a statement taken correctly, and changed it into mathematical symbols clearly and precisely.

References
[1] Yahya M 2018 Era Industri 4.0: Tantangan dan Peluang Perkembangan Pendidikan Kejuruan Indonesia Scientific Oration by Professors of Vocational Study Department The State University of Makassar.
[2] Salwah 2014 Peningkatan Kemampuan Berpikir Kritis Matematis dan Habit of Striving for Accuracy and Precision melalui Pendekatan Realistic Mathematics Education berbasis Gaya Kognitif Siswa Kelas VII SMPN 5 Bandung (Bandung: UPI)
[3] Burden P R and Byrd D M 2010 Methods for Effective Teaching: Meeting the Needs of All Students, fifth edition (Boston: Pearson Education)
[4] Usodo 2011 Profil Intuisi Mahasiswa dalam Memecahkan Masalah Matematika Ditinjau dari Gaya Kognitif Field Dependent dan Field Independent. Proceeding of Mathematics and Mathematics Education International Seminar UNS
[5] Agoestanto A, Sukestiyarno Y L, and Rochmad 2017 Analysis of mathematics critical thinking students in junior high school based on cognitive style Journal of Physics: Conference Series 824 012052
[6] Fachhrurazi 2011 Penerapan pembelajaran berbasis masalah untuk meningkatkan kemampuan berpikir kritis dan komunikasi matematis siswa sekolah dasar Jurnal Nasional, Special
Edition 76-89.

[7] Ennis 2001 Critical Thinking Assessment (Cresskill, N.J.: Hampton Press)
[8] Korres K and Tsami E 2010 Supporting the development of critical thinking skills in secondary education through the use of interdisciplinary statistics’ and mathematics’ problems Journal of Interdisciplinary Mathematics 13 491-507
[9] Kusumah 2014 Kemampuan berpikir logis mahasiswa dalam perkuliahan matematika dasar dan matematika diskrit Proceeding of Mathematics National Conference XVII ITS, Surabaya.
[10] Cao Y 2006 Effects of field dependent-independent cognitive styles and cueing strategies on students recall and comprehension dissertation (Virginia: Virginia Tech)
[11] Faradillah A, Hadi W, and Tsurayya A 2018 Pre-service mathematics teachers’ reasoning in solving mathematical non-routine problem according to cognitive style Journal of Physics: Conference Series 948 012006
[12] Haryani 2012 profil proses berpikir kritis siswa SMA dengan gaya kognitif field independent dan berjenis kelamin perempuan dalam memecahkan masalah matematika Proceeding of SNMPM, University of Sebelas Maret