

Analysis the Students' Decision-Making Style in Mathematical Critical Thinking Skill

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Abstract: The purpose of this research is to know students' critical thinking skill on two-variable linear equation topic at VIII grade in order to recognize characteristics of the students' thinking based on decision-making style. Method of this research is a qualitative case study by using descriptive type. Data are collected by using test and interview. The results find that based on the category of students' critical thinking skill, Student 1 is in the moderate category, Student 2 is the low category, Student 3 is the high category, and Student 4 is the very low. Consequently based on the decision-making style, Student 1 and Student 2 have directive style, Student 3 has analytic style, and Student 4 is behavioral style.

Key words: *Higher order thinking skill, Critical thinking skill, Decision-making style*

INTRODUCTION

The one of education purpose is for developing the entire students' potential, so they are capable of solving any problems in the various situation in real life. This statement will be found in the Law Number 20 of 2003 on National Education system:

“Education means conscious and well-planned effort in creating a learning environment and learning process so that learners will be able to develop their full potential for acquiring spiritual and religious strengths, develop self-control, personality, intelligence, morals and noble character and skills that one needs for him/herself, for the community, for the nation, and for the State”.

Next, in PP Number 17 of 2010 was emphasized that the main purpose of national education is developing the students' potential in order to be an individual that is knowledgeable, capable, critical, creative and innovative.

The students' potential is related to a cognitive development. According to Wells, “Cognitive development is the construction of thought process, including remembering, problem solving, and decision making, from childhood through adolescence to adulthood” [1].

Decision-making is one of a crucial phase of the thought process. It is not a single process, but it is a compound process consisting in seven steps, which are: appreciating of a problem, gathering of information and data, analysing of data and information, developing of alternatives, evaluating of these alternatives, and finally choosing of appropriate alternative [2].

Al Shra'ah in his research explained that decision-making is a tool for training of future leaders because participation in decision-making process improves leadership style and capacities. Being a good decision maker will lead students being a successful man in future because decision making process is considered as the process of choosing the best alternative for reaching objectives in real life [2].

According to Rowe and Richard, decision-making styles are expressed into four categories and dimensions, namely; Firstly, *Directive* – this style tends to use data that is based on fact and prefer structure. Secondly, *Analytic* - this style tends to over-analyze a situation to find the best possible solution. Thirdly, *Conceptual* – this style characterize creative and a wide outlook. Finally, *Behavioral* – this style is considered as the most people-oriented style. It means that behavioral tends to give an opinion and its form is unstructured [3].

By classifying the students' decision-making style, then it will aid them to find their thinking characteristic. Furthermore, it will help them to change their mindset

and also train their thinking way to have a high cognitive complexity. Hollingsworth explained that by proposing high cognitive complexity, students would have the capability to understand the world in more complex ways [4]. In other words, cognitive complexity can be described as a way done by an individual in viewing an event by analyzing based on cognition process, thought and structure they have [5].

In the educational setting, the decision-making can be found in mathematical critical thinking skill. In this learning, the student will be guided to improve their abilities, such as a higher level of concentration, more in-depth analytical abilities, and improved thought processing [6].

To Ennis, "Critical thinking is the reasonable and reflective thought focused on what to believe and do" [7].

Some writers like Glaser, Primack, and Wilson believed that critical thinking ability would influence directly the capacity for individuals to advance in applying a piece of information effectively in order to they are able to decide the best alternative solution of any problems [8]. The critical thinking is the significant process of taking a decision. The skill possessed by students will encourage them to have the independent attitude in solving any problems so it can stimulate the decision-making process optimally.

Rajarendra, as well as Aizikovtsh & Amit, stated that mathematics is one of the subjects that can make be more advanced in critical thinking skills. The similar thing also expressed by Heningsen and Stein, "Mathematics learning can develop critical thinking skill in mathematics requires complex mathematical task that can encourage higher thinking skill"[9].

All statements of some experts above declare that mathematics can develop the students' mathematical critical thinking skill by providing them with the exercises and tasks including indicators of mathematical critical thinking skill. Thus, if the students' critical thinking skill improve, then it can influence their decision-making style.

THEORETICAL FOUNDATION

Decision Making Process

The term 'decision making' means an outcome of mental process guiding an individual to do the action of carefully choosing several alternatives. These several alternatives will be evaluated to produce the final solution in a stage of the decision-making process.

Similar to the definition of decision making expressed by Dumler and Skinner that the decision-making process is "A choice among competing alternatives and the implementation of the chosen alternatives" [2].

Decision making is also called as a cognitive process leading to the process of choosing several alternatives to obtain the best solution. Goodyear stated:

"It is important to note that decision making is primarily a cognitive process that combines the mental process of perception, action and coming to closure on stimuli. Cognitive style, on the other hand, is the patterning or linking of these thinking processes and coming to closure the presence of ambiguity and uncertainty" [2].

To sum up, the decision-making process is a way done one to process and organise information and finally will arrive at a judgement or conclusion as the final solution based on their problems.

Decision-Making Style

Decision making is a cognitive response expressing the way and manner a decision maker to think and respond a the differences of decision situation to address the problem [3].

Rowe and Boulgarides defined, "*Decision-making style as the way one visualizes and thinks about situation. It is the way we perceive and comprehend stimuli and how we choose to respond*" [10].

Then, Rowe and Richard formulated decision style into four categories and dimensions, namely [3]:

- a. Directive, in this style, students will formulate any problems by using data that is based on fact. Its form is structured. There are some characteristics possessed by students in this style, which are: (1) students tend to work based on task-oriented, (2) students tend to own power or quality to decide a problem, (3) students work quickly, and (4) students work in an organized manner without wasting time, money, and energy.
- b. Analytic; this style has a tendency to over-analyze a situation to find the best possible solution. In this style, students tend to be more technical, to see things in detail, and may eventually become autocratic.
- c. Conceptual; in this style, students will tend to think creatively about solving any problems. In addition, they also have a wide outlook. There are some characteristics possessed by them, which are: (1) their thought depend on feelings and intuition, (2) they prefer to do the discussion and are willing to compromise, (4) they have the sense of curiosity, open-minded, independent, and dislikes rules and regulations.
- d. Behavioral; students tend to offer opinions in this style. Moreover, it has the unstructured pattern. They have the social decision-making style; it means that their decision purpose for the sake of other people and lose control. In other words, it has the strong emphasis on values and ethics.

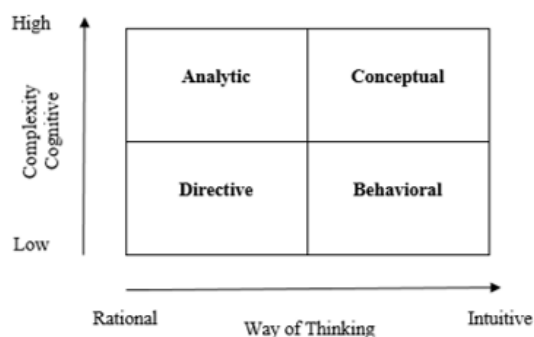


Fig 1 Decision-making matrix

Critical thinking

The father of critical thinking, John Dewey, defined the critical thinking as ‘reflective thinking’ that have a definition as follows:

“Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends, constitutes reflective thought... It is a conscious and voluntary effort to establish belief upon a firm basis of reason” [11].

According to Gokhale, the critical thinking is a thinking process involving the actions of analysis, synthesis, and evaluation concept [12].

On the other hand, Ennis, Henri, and Garisson formulated their theories of critical thinking as a problem-solving process. There are five stages involving this process, which are: focusing and observing on a question or problem, asking and answering questions for clarification of problem, judging and understanding the situation of the problem, analysing the problem, making and evaluation decisions or solutions, and finally deciding on an action [8].

Moreover, Facione described the critical thinking process in six competencies, namely [13]:

1. Interpretation – comprehend and express the meaning of the variety of situations, experiences, data, judgements, procedures, belief or criteria
2. Analysis – identify the inferential and actual relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express belief, judgement, experiences, reasons, information, or opinions.
3. Evaluation – asses credibility of statements or other representation of person’s perception, experience, situation, judgement, belief, or opinion, as well as evaluate the strength of the actual or inferential relationships among statements, descriptions, questions or another form of representation is called an evaluation phase.
4. Inference - identify and secure elements to conclude reasonable conclusions; state conjecture and hypothesis; as well as deduce the consequences

following from data, statements, evidence, judgments, belief, opinions, concepts, descriptions, questions, or another form of representation.

5. Explanation - present the results of reasoning to justify that the arguments used that came from the evidential, conceptual, methodological, and contextual considerations.
6. Self-regulation – it consists of self-examination and self-correction to monitor cognitive activities, elements used in learning activities, and results deduced.

Through approaching FRISCO (Focus, Reason, Inference, Situation, Clarity, and Overview), Ennis formulated six basic elements of critical thinking, which are; Firstly, *Focus* – introducing some situation. Secondly, *Reason* – supporting the conclusion. Secondly, *Inference* – assessing the acceptable and sufficient to make a decision. Next, *Situation* – having the supporting situation such as both physical and social environment. It is not only thinking activity but also the meaning of what to hold and to assess by the thinker. Another step is *Clarify* – explaining the clear and explicit message will avoid ambiguity. The final step is *Overview* – verifying the final decision [14].

METHOD

Design research

The method of research is a qualitative case study by using descriptive type to analyse the decision-making style of students’ mathematical critical thinking skill. In this research, there are four students as subjects studied and they are students in VIII grade of Junior High School.

Instruments

The instrument of research is a test consisting of indicators of mathematical critical thinking skill. The topic is a two-variable linear equation. The following table shows the indicators of students' critical thinking ability:

Table 1 Indicators of Mathematical Critical Thinking Skill.

Indicators	Explanation
Interpretation	Understanding problem by writing what information obtained from the question.
Analysis	Identifying the relations among statements, questions, and concepts given by expressing them in the mathematical model and presenting the arguments correctly.
Evaluation	Using the correct strategy to solve the questions and doing the calculation correctly and completely.
Inference	Stating the correct conclusion.

To obtain the data of students’ mathematical critical thinking skill, then there are the rules of scoring used to

score the students' answer. The criteria of scoring is a rubric score modified by Facione and Ismaimuza [13].

Table 2 Rubric Score of Mathematical Critical Thinking Skill.

Indicators	Explanation	Score
Interpretation	• Student did not write what known and asked the question.	0
	• Student wrote what known and asked the question, but their answer is not correct.	1
	• Student wrote what known and asked the question correctly, but their answer is not complete.	2
	• Students wrote what known and asked the question correctly and completely.	3
Analysis	• Student did not make the mathematical model of the question given	0
	• Student made the mathematical model, but their answer is not correct.	1
	• Student made the mathematical model correctly, but their answer is not complete.	2
	• Student made the mathematical model correctly and completely.	3
Evaluation	• Student did not use the strategy in solving question.	0
	• Student used the strategy, but their strategy is not correct.	1
	• Student used the strategy correctly but their strategy is not complete.	2
	• Student used the strategy correctly and completely.	3
Inference	• Student did not make a conclusion.	0
	• Students made a conclusion, but their conclusion is not correct.	1
	• Students made a conclusion correctly, but their conclusion is not complete.	2
	• Students made a conclusion correctly and completely.	3

The way of the calculation of percentage values is as follows:

$$\text{Percentage} = \frac{\text{Score obtained}}{\text{Maximal Score}} \times 100\%$$

The value of the percentage of the students' critical thinking skill obtained from the calculation above will be categorized according to the table below:

Table 3 Category of Percentage of Mathematical Critical Thinking Skill.

Interpretation (%)	Category
$81,25 < X \leq 100$	Very high
$71,5 < X \leq 81,25$	High
$62,5 < X \leq 71,5$	Moderate
$43,75 < X \leq 62,5$	Low
$0 < X \leq 43,75$	Very low

After assessing the students' answer sheet based on the indicators of mathematical critical thinking skill, then the students' answer sheet will be analysed according to the decision-making style. The types of decision-making used in this study are as follows:

Table 4 Types of Decision-making style.

Types	Explanation
Analytic	This style represents that student will solve a problem by more accurate and more detail, well structured and more technical.
Directive	This style represents that student will formulate any problems by using data that is based on fact. Its form is structured.
Conceptual	This style represents that student are creative and a wide outlook in solving a problem.
Behavioral	This style represents that student tends to give an opinion and unstructured.

RESULTS AND DISCUSSION

In this research, there are four students as subjects studied and they are students in VIII grade of Junior High School. The topic is two-variable linear equation including the indicators of critical thinking skill.

Based on the result of the scoring of critical thinking skill, it was found that Student 1 is in the moderate category, Student 2 is the low category, Student 3 is the high category, and Student 4 is the very low category. Here is shown result of scoring each student:

Table 5 Score and Percentage of Student's Mathematical Critical Thinking Skill.

Indicators	Student			
	1	2	3	4
Interpretation	0	0	3	0
Analysis	3	3	3	1
Evaluation	3	3	3	1
Inference	2	0	3	1
Total	8	6	12	3
Percentage	66.7%	50%	100%	25%

Note: Maximal score = 12

Based on the students' answer sheet found that there are three students could answer the question correctly whereas one student could not answer it. But, if their answer is assessed based on the indicator of the critical thinking skill found that that Student 1 is in the moderate category, Student 2 is the low category, Student 3 is the high category, and Student 4 is the very low.

For instance, consider the following problem: Given the width of a rectangle is 4cm shorter than its length. If the circumference of the rectangle is 32 cm, then determine the length of the rectangle!

Student 1 was able to answer the question correctly. According to the indicators of critical thinking skill, Student 1 fulfill 3 (three) indicators, which are: analysis, evaluation and inference. While on the interpretation phase, he did not do. Based on the interview result, he assumed that the initial phase, interpretation, is not an important step in solving the problem because he could solve this question correctly. However, the interpretation phase in critical thinking did not fulfilled by him. It can conclude that his answer is structure and based the fact on making the correct mathematical model and doing the correct calculation. Hence, he adequates the *directive* style in decision-making style.

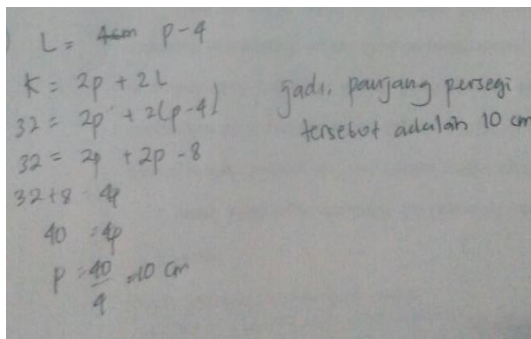


Fig 2 The answer sheet of Student 1

Student 2 answered the question correctly, but he only fulfilled 2 (two) indicators of the critical thinking skill, those are analysis and evaluation. He did not do interpretation and inference phases. Based on the

student's answer sheet, he just focused to make the mathematical model and calculate the answer. According to the result of the interview, he has been understood the problem given. He assumed these phases (interpretation and inference) were not the crucial phases in solving the problem. Even so, both indicators were fulfilled in the interview session indirectly, but if it was reviewed from the critical thinking skill in writing, he has not succeeded in both indicators because he did not write these phases on his answer sheet. Consequently, he is appropriate as the *directive* style, in which the result of the interview also found that he solved the problem quickly and his answer was enough organized without wasting time.

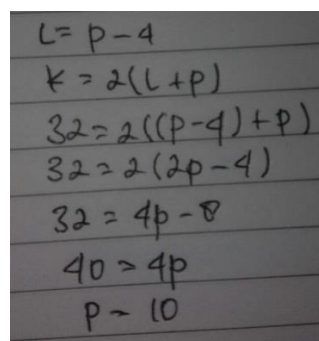


Fig 3 The answer sheet of Student 2

Student 3 could solve the question well. He met all indicators of the critical thinking skill, which are: interpretation, analysis, evaluation, and inference. Based on the interview result, he has also been able to provide a reason for the conclusion obtained. Therefore, he is acceptable in the *analytic* style because he has found a solution technically in more detail and well structured.

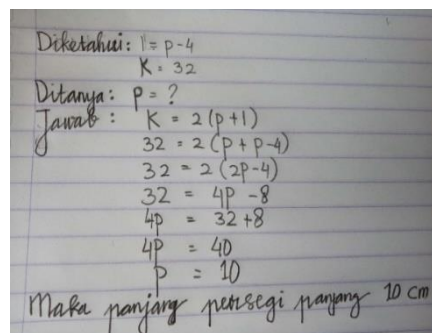


Fig 4 The answer sheet of Student 3

Student 4 has not been understood the problem well. This happened because he was incapable of drawing conclusions or relationships among the data or information provided on the question. This expressed that the first and second phases of the critical thinking, i.e. interpretation and analysis were not achieved. As a result, the Thus, he is categorized as the *behavioral*

style. This style showed that he was able to solve the question by he was able to work on the problem by making use of his opinion without being based on a clear and precise concept so that the resulting answer has an unstructured form.

The case above showed that in solving problems, we must do the step by step the phase of the critical thinking indicators, such as the initial phase, interpretation, will make students easier to make a mathematical model, then find the best strategy to solve and do the calculation, and finally student can take the best alternative solution to the problem. If we were missed only one phase, it could affect the final solution.

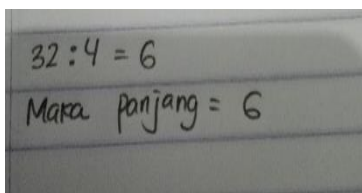


Fig 5 The answer sheet of Student 4

CONCLUSION

Based on the category of students' critical thinking skill, Student 1 is in the moderate category, Student 2 is the low category, Student 3 is the high category, and Student 4 is the very low. As a result, based on the decision-making style, Student 1 and Student 2 have directive style, Student 3 has analytic style, and Student 4 is behavioral style.

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