

CRITICAL THINKING PROCESSES OF JUNIOR HIGH SCHOOL STUDENTS IN SOLVING CONTEXTUAL PROBLEMS OF DIRECT AND INVERSE PROPORTIONS BASED ON REFLECTIVE-IMPULSIVE STYLE

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Abstract

Critical thinking is one of essential components in mathematics learning and its process becomes the focus to improve students' critical thinking. In mathematics instruction, mathematics cannot be separated from problem solving, and critical thinking helps them in such a thing. Contextual problem is one of various problems which is related to context in a real life and can be found easily in topic direct-inverse proportions. This kind of problem gives opportunity to think more critically to find the solutions. When solving problems, students proceed information differently and it is affected by their cognitive style. One-dimensional model of variation in cognitive style is reflective-impulsive style. The purpose of this research is to describe the critical thinking processes of reflective and impulsive junior-high-school-students in solving contextual problems of direct and inverse proportions. This research is descriptive qualitative research; using test and interview methods to collect the data. The results showed that both students with reflective and impulsive style did all the phases in critical thinking proposed by Facione. Yet, there are some differences on how they go through each of those phases: (1) both students conduct interpretation by categorizing what are given and asked, but the reflective students clarify meaning in detail, while the impulsive students not in detail; (2) the reflective students analyze well by examining ideas and identifying arguments as well as reasons, while the impulsive ones do not analyze well that is caused by inability to find unstated information; (3) both students do inferences by querying evidence, forming hypothesis, and trying to prove the hypothesis and to draw a conclusion, but in querying evidence, the reflective students mention the relevant-irrelevant information confidently and use all relevant information to solve problem, while the impulsive student got confused in distinguishing between them; (4) both students carry out evaluation by assessing credibility of claims and quality of arguments before jumping to the next steps, yet the impulsive ones do not take any further actions; (5) the reflective students do explanation by stating results, justifying procedures, and presenting arguments clearly, while the impulsive students not clear (6) the reflective students always perform self-regulation by doing monitoring and correcting what they have done, while the impulsive ones barely perform self-regulation.

Keywords: critical thinking process, contextual problem, direct and inverse proportions, reflective-impulsive style.

INTRODUCTION

In the 21st century as problems have become more complex caused by many challenges provided, people need to have higher quality in thinking in order to solve problems they face and having critical thinking is an realization of it (Rasiman and Pramadyahsari, 2014:537). Through critical thinking, an individual would be able to solve problems better since they would have the ability and tendency to gather, evaluate, and use information effectively (Stockard, 2007). Thus, critical thinking must be presented on a regular basis, even in the classrooms which will train

students to solve problems provided by teachers. Critical thinking and problem solving are some of learning and innovation skills that have to be mastered by students in the 21st century besides creativity and innovation, communication and collaboration. By having critical thinking, the students will use logical reasoning to interpret, analyse and evaluate information until they take reliable and valid decisions (Chukwuyenum, 2013). As a result, the students are expected to learn and perform better when they think critically about the subject they are studying. Considering the importance of critical thinking, it has also been become one of the primary focuses in mathematics

learning. In Indonesia, the standard competence for students in learning mathematics states that students have to be able to think logically, analitically, sistematically, critically and creatively, and be able to work in group.

Ulya et al. (2014) said that mathematics cannot be separated from problem solving. While Jacob and Sam (2008) argued that the activities of critical thinking are often associated with problem solving. From those two statements, it can be concluded that mathematics, problem solving and critical thinking show relationship to each other. Students who get used to solve mathematics problems will improve their critical thinking. Otherwise, critical thinking can support students to solve problems in mathematics. Among the various problems that can be provided in mathematics classroom, contextual problem could be the best choice for teachers to develop students' critical thinking. Such problem is related to context in a real life. According to Gravemeijer & Doorman (1999), a context has important role since it becomes a starting point of learning for students to explore mathematical notions in a situation that is experientially real. By engaging students in "real life" problems, it gives opportunity to students realizing how close their life with mathematics and how much mathematics contributes in their life so that they will think that it is important to solve such problems. In consequence, they will try to find the solutions of given problem seriously and think more critically. It indicates that the situations provided in the contextual problems can be utilized to encourage critical thinking of students.

For teaching improvement, evaluation of teaching is needed. After providing some problems to the students to solve, teacher needs to evaluate what was happening when students were thinking during solving given problems. In other words, it is important to know students thinking processes while they are completing the task. By understanding the students' thinking processes, teacher is expected to know what kind of learning strategies can be used to improve teaching and learning. In mathematics learning, thinking process plays a role since it helps students to understand the abstract of mathematical basic objects which are facts, concepts, relations/operations and principles. In this case, students' critical thinking process is necessary to reveal, while they are solving contextual problems.

Students think in different ways as they perceive and remember information differently (Sellah *et al*, 2017:10).. It is known as cognitive style that affects how students interpreting and proceeding some information. It implies that every student has different thinking process based on their cognitive style, in consequence, students' critical thinking process must be different as well. One-dimensional model of variation in cognitive style is reflective-impulsive proposed by Kagan (1965). He said

that those who are relatively show and highly accurate in their work are called reflective, while those who work both quickly and with errors are impulsive. Further, studies find that reflective students were higher scoring than the impulsive category in elaboration, originality, and overall capacity for critical thinking. Therefore, there must be differences between reflective and impulsive students' critical thinking processes. This research will reveal what is happening when reflective and impulsive students are thinking critically.

Critical thinking cannot be seen while completing ordinary tasks. Some challenging tasks are needed to encourage students to think critically and proportions is one of the most mathematically complex and cognitively challenging topic in the school curriculum (Ben-Chaim *et al.*, 2012). Besides, many contextual problems can be found in this topic. It implies that proportion, included direct and inverse proportions, can facilitate students' critical thinking.

By referring to the newest version of Facione's theory of critical thinking, the result of this research is expected to be able to represent the critical thinking processes of students nowadays. In addition, the criteria to assess the students' critical thinking are derived more detail from each sub skill of critical thinking presented by Facione. There are total 24 criteria derived from 6 skills of critical thinking which are interpretation, analysis, inference, evaluation, explanation, and self-regulation. Those skills are developed as indicators to assess critical thinking processes of students. The table below shows indicators for identifying critical thinking processes of students.

Table 1. The Indicators of Critical Thinking Process

Indicators	Sub Indicators	Criteria
Interpretation	Categorize	<ul style="list-style-type: none"> Mention what are given. Mention what are asked.
	Clarify meaning	<ul style="list-style-type: none"> Describe the problem in own words.
Analysis	Examine ideas	<ul style="list-style-type: none"> Mention unstated information of a given problem.
	Identify arguments	<ul style="list-style-type: none"> Identify the relationship among information given in the problem. Identify the relationship between what are given and asked of a provided problem.
	Identify reasons and claims	<ul style="list-style-type: none"> Mention the reason of choosing certain

Indicators	Sub Indicators	Criteria
		approaches/strategies to the solution.
Inference	Query evidence	<ul style="list-style-type: none"> Determine relevant and irrelevant information to draw reasonable conclusions. Consider relevant information and ignore the irrelevant ones.
	Conjecture alternatives	<ul style="list-style-type: none"> Form conjectures and hypothesis.
	Draw conclusions	<ul style="list-style-type: none"> Educe the consequences flowing from data and opinions. Make a conclusion as the final result of solving problem.
Evaluation	Assess credibility of claims	<ul style="list-style-type: none"> Assess the logical strength in interpreting problem. Judge the credibility of conclusion.
	Asses quality of arguments	<ul style="list-style-type: none"> Assess the applicability of strategies have been devised. Assess the strength of each step has been taken in solving problem.
Explanation	State the results	<ul style="list-style-type: none"> State the strategies have been devised State final results as a solution of given problem.
	Justify procedures	<ul style="list-style-type: none"> Justify every step of certain strategy to solve problem
	Present arguments	<ul style="list-style-type: none"> Present arguments of identifying the relationship between given information and strategies to solve problem
Self-Regulation	Self-monitor	<ul style="list-style-type: none"> Monitor the degree to which the understanding in interpreting problem. Reconsider the judgement in view of further analysis.

Indicators	Sub Indicators	Criteria
	Self-correct	<ul style="list-style-type: none"> Revise the answer in view of errors discovered. Change the conclusion in view of the realization of misjudgement.

METHODS

Based on the goal of this research which was describing critical thinking processes of students, it was used descriptive research with qualitative approach to carry out these plans of research. Test and interview methods were used to collect the data, while the subjects consisted of 2 students with reflective and impulsive style. To choose these two subjects, students were given MFFT to classify them into reflective or impulsive students.

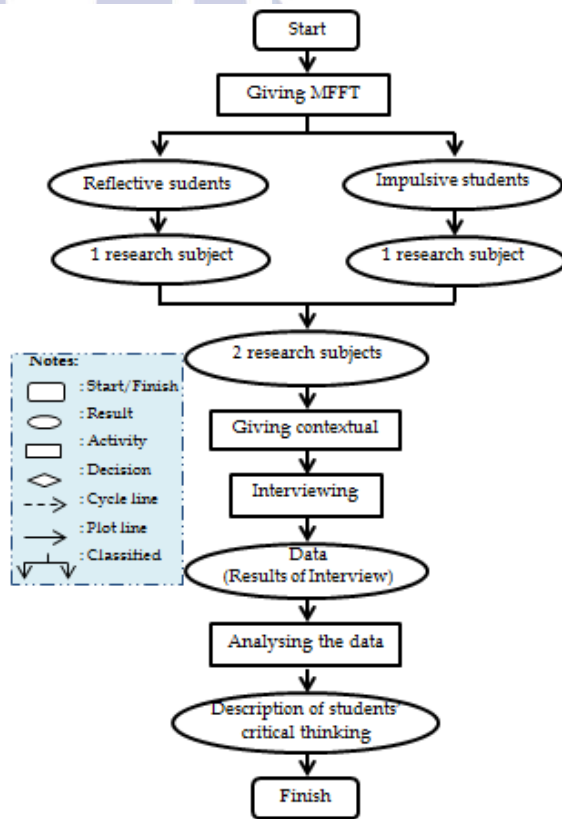


Figure 1. The Flow Chart of Research Design

After the data were collected from the test and interview results, they were analyzed to draw a conclusion. The data analysis involved three concurrent flows of activity.

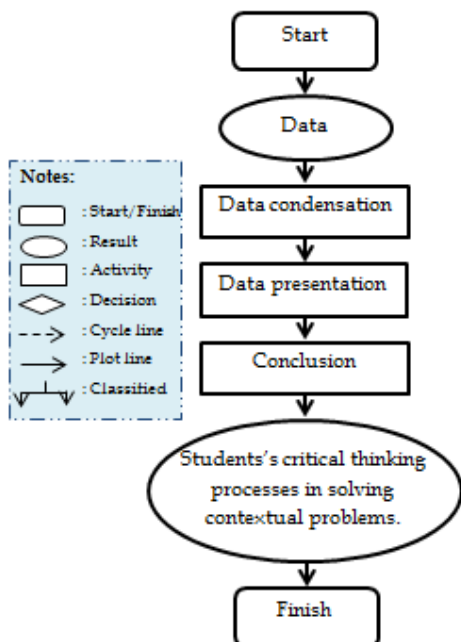


Figure 2. The Flow Chart of Analysis Data

During data condensation, the data as results of MFFT, written test, and interview were selected, simplified, and transformed into certain ways/forms. They also separated into necessary and unnecessary ones. The necessary data were then presented in passage, table, and also figure. This phase was called data display which allowed to get a general sense of information and to figure out what was happening so that a conclusion was easily found. From data had been displayed, some conclusions were taken corresponding to the indicators of critical thinking processes for this research.

RESULT AND DISCUSSION

MFFT results showed that reflective and impulsive style are greater than the number of students with fast-accurate and slow-inaccurate. It can be seen from table below that there are 37.5% reflective students and 34.375% impulsive students. The sum of these percentages is consistent to the research result of Al Silami (2010) saying there are about 70% students in reflective-impulsive group. It means the reflective-impulsive students are dominant compared to the remaining cognitive style. Therefore, the focus of this research is on reflective and impulsive students.

Table 2. The Percentage of Students' Cognitive Style

Reflective	Impulsive	Fast-Accurate	Slow-Inaccurate
12 students	11 students	5 students	4 students
37.5%	34.375%	15.625%	12.5%
71.875%		28.125%	

In this research, instead of using the mean, the median of initial responses (latency) was calculated. The calculation shows that the latency is 749. It means that students who can complete the test less than 749 seconds, they can be called "fast". Otherwise, if they take more than 749 seconds to complete the test, they are "slow". The number of errors (accuracy) indicates whether students are accurate or not. If the students' errors are less than 16, they can be called "accurate". Otherwise, if the errors are more than or equal to 16, they are "inaccurate". Further, students are classified into these four categories:

- Reflective (slow and accurate)
- Impulsive (fast and inaccurate)
- Fast-accurate
- Slow-inaccurate

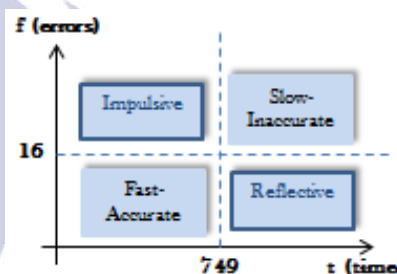


Figure 3. Classification of Reflective-Impulsive Students

Choosing subjects begins with eliminating fast-accurate and slow-inaccurate students, remaining reflective and impulsive students only. Then, the reflective subject is chosen by considering a student who takes so long to respond (the latency was so big), yet the number of errors (accuracy) approaches to zero. Besides, the gender and mathematics score of subjects are considered in order to reduce the bias.

Table 3. The Chosen Research Subjects

Latency	1377	544
Accuracy	3	19
Cognitive Style	Reflective	Impulsive
Gender	Female	Female
Mathematics Mark	88	85
Initial Name	FMM	YPP
Code	SR	SI

Table 4. The Comparison of Students' Critical Thinking Processes with Reflective and Impulsive Style

No	Indicators	Sub Indicators	Cognitive Style	
			Reflective	Impulsive
1.	Interpretation	Categorize	Mention what are given and asked in detail and in order.	Mention what are given and asked incompletely.
		Clarify meaning	Describe the problem in own words clearly	Mention what are given and asked incompletely.

No	Indicators	Sub Indicators	Cognitive Style		No	Indicators	Sub Indicators	Cognitive Style	
			Reflective	Impulsive				Reflective	Impulsive
2.	Analysis	Examine ideas	Mention unstated information.	Mention stated information only.				relationship between given information well and clearly .	relationship between given information not well enough .
		Identify arguments	Identify the relationships among information given in the problem.	Identify the relationships among information given in the problem.				Reconsider the judgement by rereading the problem and calculating several times.	Reconsider the judgement by rereading the problem and calculating several parts (some parts only).
		Identify reasons and claims	Mention the reason of choosing certain strategy.	Mention the reason of choosing certain strategy.				Self-correct	Revise the answer and change the conclusion in view of errors and misjudgement
3.	Inference	Query evidence	Determine and consider relevant-irrelevant information confidently .	Determine and consider relevant-irrelevant information in confusion and doubt .					
		Conjecture alternatives	Form hypothesis and try to prove it .	Form hypothesis and sometimes do not even try to prove it .					
		Draw conclusions	Educe the concequences flowing from data.	Educe the concequences flowing from data.					
4.	Evaluation	Assess credibility of claims	Assess the credibility in interprating problem by rewriting every given information and what is asked. Judge the logical strength of conclusion.	Assess the credibility in interprating problem without taking any further action to have a better understanding . Judge the logical strength of conclusion.					
		Assess quality of arguments	Assess the applicability of strategies have been devised by writing it down .	Assess the applicability of strategies have been devised by writing it down and sometimes just thinking of it .					
		State the results	State the strategies have been devised in detail .	State the strategies have been devised not in detail .					
		Justify procedures	Justify every step of certain strategy (systematical ly).	Justify some steps only of certain strategy.					
		Present arguments	Present arguments of identifying the	Present arguments of identifying the					

Critical Thinking Processes of the Reflective Subject

Reflective subject was able to categorize informations as what were given and asked. Not only that, she mentioned important information only yet the information included were in detail and ordered. She could interpret the problem clearly and describe the situation of the problem in her own words.

During the step of analysis, the reflective subject tried to discover unstated information of a given problem. By associating those stated and unstated information, the subject identified the relationships among them and took certain approach/strategy followed by the reason/claim behind their action.

Relevant-irrelevant information could be determined because the reflective subject was able to distinguish between those two. From the relevant information combined with their opinions, she inferred the consequences. The reflective subject formed a hypothesis that would be followed by some proofs. She tried to know if their claims were correct. Finally, this hypothesis arrived as an inference (conclusion) if it was tested already and was true.

Before jumping to the next step, the reflective subject always did evaluation by assessing credibility of claims and quality of arguments. They assessed the logical strength in interparting problem, assessed the applicability of strategy had been devised, assessed the strength of each step had been taken, and judged the credibility of conclusion as the final result.

Not only chose certain strategies and took some steps to solve problem, but the reflective subject could also state the strategies and justify every step. They were able to present arguments and state final results clearly and precisely as parts of activities in explanation.

Self-regulation was well done by the reflective subject. She considered her judgment carefully, so that she could find some mistake if any and tried to revise the answer and change the conclusion.

Critical Thinking Processes of the Impulsive Subject

In interpretation, the impulsive subject was able to categorize informations into what were given and what was asked. Yet they did not include all information. One or two information was often missed by them. The subject interpreted the situation of the given problem quite well but she focused more on text given and also still mentioned irrelevant information. In other words, she was not too good while describing in her own words.

For analysis, since the impulsive subject did not try to discover unstated information of the given problem, she was not able to identify the relationship among informations completely. She could connect those informations but she could not get the perfect ones. Strategies or approaches which she took were often not followed by certain reason.

Since the impulsive subject was low in distinguishing between relevant and irrelevant informations, she was also low in determining which one and another. However, they did not use the irrelevant information to solve problem, she was just not able to present reason behind it. The same thing happened while she was forming a hypothesis. The hypothesis might be correct but she did not follow it by some proof. Therefore, she arrived to a weak conclusion.

It could be said that the impulsive subject did evaluation activities. She assessed her claims and arguments, but she did not do further actions. She kept going although she knew that her judgments were not that strong.

As said before, the impulsive subject often held her believe eventhough she did not know the reason of it. She preferred to finish the problem fast rather than did it correctly. In other words, she was not sure while stating either the strategies or steps had been taken.

Self-regulation was not executed by the impulsive subject well. She was not careful enough, so that she failed to find some mistake.

CLOSURE

Conclusion

Both reflective and impulsive students pass all the phases of critical thinking. Yet, their performances are quite different: (1) the reflective students clarify meaning in detail and in order; describe the problem in own words clearly (2) since the impulsive students are unable to find unstated information, they cannot do analysing well; (3) the reflective students are very confident in distinguishing relevant-irrelevant information, and form hypothesis and

try to prove it; (4) the impulsive students do not take any further actions after assessing credibility of claims, and assess the applicability of strategies have been devised by writing it down and sometimes just thinking of it; (5) the reflective students state the strategies have been devised in detail, justify every step of certain strategy systematically, and present arguments of identifying the relationship between given information well and clearly; (6) the impulsive students reconsider the judgement by rereading the problem and calculating several times (some parts only), they barely performed self-regulation. Based on those performances, it can be inferred that reflective students perform better compared to impulsive students in all phases of critical thinking.

Suggestion

In consonance with the conclusion and the research weaknesses that had been explained before, it can be suggested these following points:

1. This research shows that there are some differences in critical thinking between reflective and impulsive students. Therefore, the teacher is strongly suggested to pay attention to the students' cognitive style, especially in reflective-impulsive domain.
2. For further relevant research, a class that students with strong critical thinking are in is highly recommended. It will help researcher to obtain more complete data since strong critical thinkers have many things to observe.
3. The MFFT must provide detail instructions so that the users/students will understand it by themselves, without any additional explanations. Also, there are some factors that are needed to pay attention to, so that the latency score of each student is accurate.
4. The proofreading of contextual problems test must include some criteria, based on certain theory, to determine whether or not the instrument is proper to use.
5. The interview guidance must be constructed and prepared really well since it is one of the important instruments to reveal unseen processes of students' critical thinking.

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