



Profile of Students' Refractive Thinking in Mathematical Problem Solving of Two-Variable Linear System

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Abstract

Refractive thinking is the thinking process to decide on several alternative solutions through reflection and critical thinking. The study is set to describe the students' refractive thinking processes in solving mathematical problems of a two-variable linear system. This is qualitative research with a qualitative descriptive method. The collected data is analyzed through three stages, namely: reduction, presentation, and verification of conclusion. The results reveal that the refractive thinking process of students from two subjects in solving mathematical problems, namely the best solution is obtained that the subject's thinking process follows the flow of the refractive thinking process. It can be determined from several alternative solutions in solving mathematical problems by using mathematical work procedures by changing story problem into a mathematical model. So that, it can be conducted quickly and precisely through the identification of the problem, strategic, and evaluation in the refractive thinking process.

Keywords: *Refractive Thinking; Problem-Solving; Math Problems*

Introduction

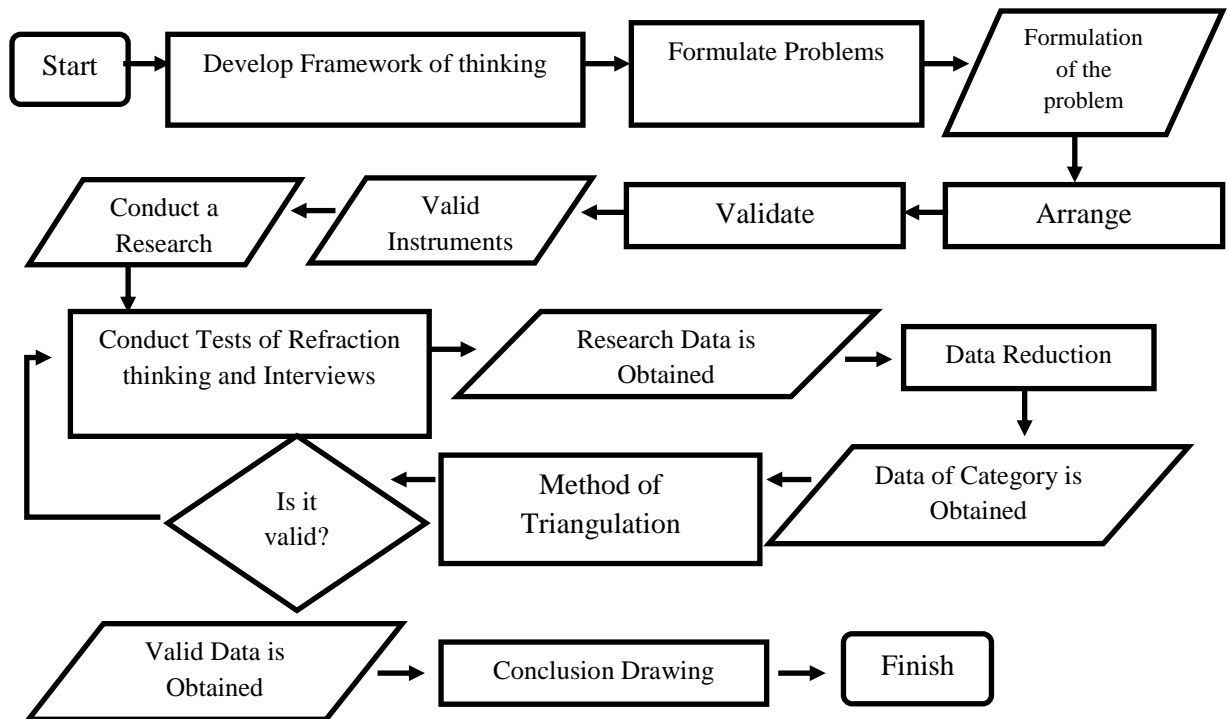
The dynamics of human life will face a cycle of problems that keep turning. The problem that comes will trigger someone to find the best solution to solve it. The process of presenting a solution is closely related to previous experiences so that each person will have different alternative solutions. The best and effective solution must be selected from several existing solutions. Determining the selected solution from several alternative solutions in the thinking process is called refractive thinking. Refraction is a thinking process to determine a decision on a problem through reflection thinking followed by critical thinking (Prayitno, 2014). Refraction is the process of changing knowledge by remembering the experiences and knowledge of a person so that it generates new thoughts (Pagano & Roselle, 2009). The ability to express opinions in mathematics can be measured by providing Open-Ended problems that require more than one answer (Lee, 2003). While the essence of refraction is determining the best solution from several existing solutions in problem-solving. The refraction process is very important because it can help students produce a decision in problem-solving (Medeni, 2012).

A light metaphor can be employed to describe the refractive thinking process that resulting from reflection and critical thinking (Downey, 2005). The components of refractive thinking are reflection and critical thinking. Reflection thinking is the beginning of refractive thinking so that when the students decide on a solution in problem-solving, they must know about selecting a solution. Students' experiences in learning can be translated into the concept of reflection (Kolb, 1984). Reflective thinking is the process of making information and logical decisions about a problem, then assessing the decision (Taggart & Wilson, 2005). Reflective thinking is a process of directed and precise activities where individuals analyze, evaluate, motivate, get the deep meaning, and use appropriate learning strategies (Gurol, 2011). Meanwhile (Lipman, 2013) the ability to think and reflect is part of the critical thinking component to think with attention to assumptions or elements. Whereas, the implications are based on reasons or evidence to support the conclusion. After reflection thinking, the next process is called critical thinking. Critical thinking is an intellectual process that actively and skillfully conceptualizes, applies, analyzes, synthesizes, and evaluates information collected or generated from observation, experience, reflection, reasoning, or communication, to guide beliefs and actions (Krutick & Rudnick, 1995).

The most important thing in critical thinking is to make decisions (Ennis, 2011). Besides, critical thinking can make a comparison and attract a conclusion (Chance, 1986), so that it can decide things to do conclusively (Costa, 1985). Thus making individuals think, question problems, generate solutions and make smart decisions in facing challenges (Semil, 2006). The third step in the knowledge development cycle is refractive thinking. The research related to refractive thinking is carried out by (Maslukha, Lukito & Ekawati 2018). The research (Maslukha, 2018) explains that the refractive thinking process of junior high school students on plane figure material. Meanwhile, the research conducted (Prayitno, 2016) explains that the refractive thinking process of senior high school students in problem-solving math through 3 stages, namely identified of problems, strategic and evaluation. This research discusses the description of the refractive thinking process of junior high school students of eighth grade. The objective of this research is to get an overview of the thinking process of 2 students in eighth grade in solving two-variable linear equation system problems. The results of this research are expected to provide information about the refractive thinking process of the students at eighth grade in problem-solving of a two-variable linear equation system. Moreover, this information can be taken into consideration for teachers in designing learning activities according to the refractive thinking characteristics of junior high school students'.

Methodology

This is qualitative descriptive research. It is a research that explores and understands the meaning of individuals related to social problems (Creswell & Creswell, 2018). The subjects in the research are 2 students of the eighth grade of SMPN 1 Maron. The sampling technique is random sampling. Description of the student's refractive thinking process originating from the student's thought process when they do the task-based test that followed by semi-structured interviews. The problem assigned to the subject is a mathematical question that deals with the material of the system of a two-variable linear equation. After obtaining the written data, interviews are conducted to clarify and explore information that might not be in the written data about students' refractive thinking processes in math problem-solving. In this research, the technique employs triangulation, which is checking data from the same source with different techniques (Sugiyono, 2016). There are two strategies, namely checking the confidence level of the research findings by using data collection techniques and checking the confidence level of data sources by the same method (Allen & Yan 1979). After the consistency of the data is collected, the data are analyzed through three stages, namely reduction, presentation, and verification of conclusions. The steps of this research are presented in Picture 1 below:

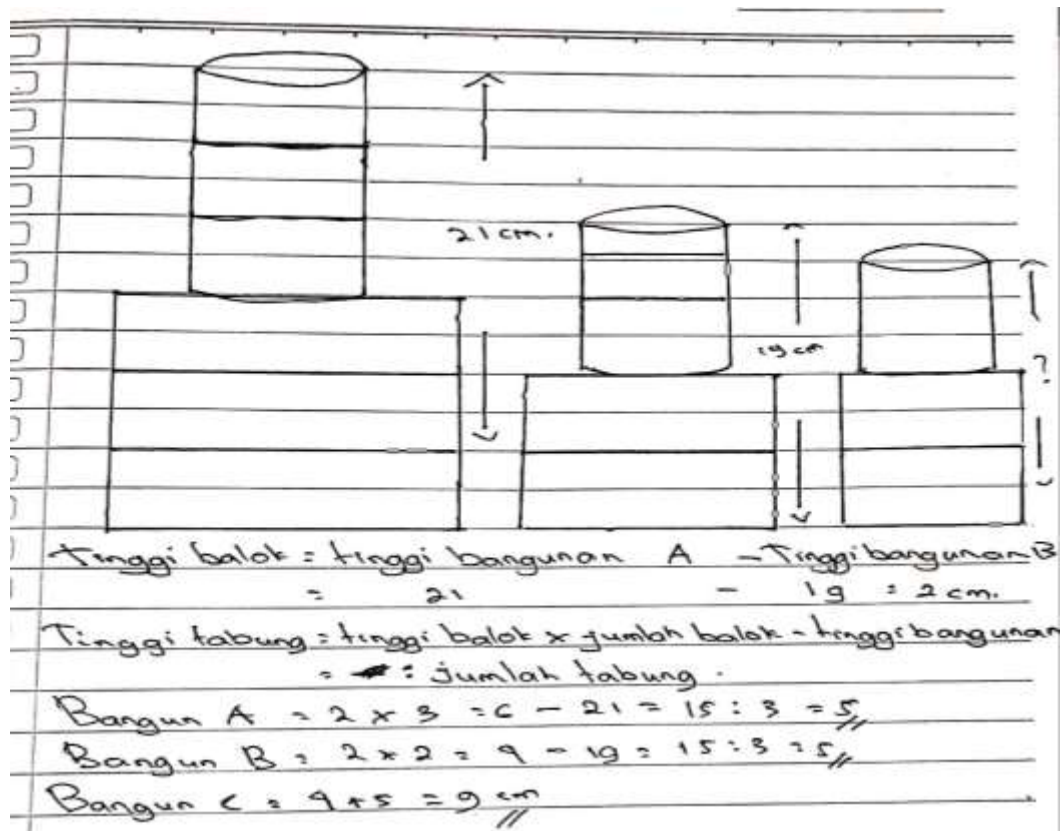


Picture 1. Flowchart

Results and Discussion

This research employs phases and indicators of refractive thinking from thinking construction results (Prayitno, 2016). There are 3 stages in the refractive thinking process, namely identified of problems, strategic, and evaluation. Based on the data analysis, it is found that the thinking characteristics of subject 1 in mathematics problem-solving can be seen in completing the task, he begins to reflect on his thoughts by describing the existing problem and identifying the problem. After that, he can explain the problems he faces, he can relate the information that he has with his problems, which means he can think critically. Furthermore, regarding the obtained relations, the subject has an idea in completing the task. The process shows that building refractive thinking begins with a reflective and critical thinking process. This process is in the early stages of the refractive thinking process, namely identified the problem (Prayitno, 2016). Furthermore, subject 1 uses the learning experience and knowledge by trying to provide answer solutions to the core of the problem by finding the length of the cylinder and cuboid tower. He thinks that the first tower has 3 cuboids and 3 cylinders, while the second tower has 2 cuboids and 3 cylinders so that the tower length is 2 meters. After that, he can find out the length of the cylinder. In the end, he can find out the shortest tower. When a deep interview is conducted, he explains the method, namely the concept of a two-variable linear equation system. This means that at the strategic stage, he does refraction thinking because he can solve the problem in more than one way. It can be proven by the explanation of how he presents the answer as shown in Picture 2.

problems that he faces then thinking critically by identifying, re-analyzing, and evaluating his strategy. And finally, he can solve the problem well. It means that at the strategic stage, subject 2 does refractive thinking because he can solve the problem. The following is the answer sheet of his problem-solving.



Picture 3. Completion Result of Subject 2

After finding two answers, subject 2 rechecks the answers that he realizes and finds errors in the first solution, so that he checks the second solution. It turned out that after comparing the first solution with the second, he believes that the easier way to illustrate images is correct and appropriate. It shows that at the stage of reexamination and determining the best solution with strong reason, he does refractive thinking. This process is included in the final stage of the refractive thinking process, namely evaluation. According to the data of subject 2, it can be seen that the thinking process can be said to be appropriate with the constructed refractive thinking flow (Prayitno, 2016) in 3 stages of refractive thinking, namely identified of problems, strategic and evaluation. In this research, he provides several alternative solutions by stating that the chosen best solution by him, is the first time he illustrates a method in the form of a story like a picture above, then he calculates it to produce the correct answer in a short time.

Conclusion

The results of this research indicate that the refractive thinking process of the students begins at identified problem stage, the students can reflect on their thinking by describing, identifying, and continuing to critical thinking, namely they can connect the information they have using a two-variable linear system that they face so that it results in a process of refraction thinking, namely they have the view related to the idea of completion that will be used to answer the tasks. The stage of Strategic is the students reflect on their thoughts by applying the information in their minds with the two-variable linear

system problem they face then it is continued to think critically by identifying, re-analyzing, and evaluating the strategy to produce refractive thinking, namely, they can solve the problems using more than one way, using elimination as in the other linear systems two-variable tasks or directly. After that, in the final stage is evaluation, the students check the answer by comparing the first solution with other solutions. After being analyzed deeply, they can determine the best solution to the problems. It shows at the stage of re-examination and determining the best solution with strong reasons that they do refractive thinking. Based on the results of this research, the teacher is expected can convey problems that have many solutions, so that they can develop their thinking in determining the best solution from several alternatives.

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