Study of student error thinking in solving Cognitive Reflection Test (CRT) required from Dual Process Theory (DPT)

S Saidi1*, P Purwanto2, A As’ari3 and S Sudirman4

1 Program Studi Pendidikan Matematika, Universitas Khairun, Jl. Bandara Babullah, Akehuda, Kota Ternate, Maluku Utara 97728, Indonesia.
2 Program Studi Pendidikan Matematika, Universitas Negeri Malang, Jl. Semarang No.5, Kota Malang, Jawa Timur 65145, Indonesia.
3 Program Studi Pendidikan Matematika, Universitas Negeri Malang, Jl. Semarang No.5, Kota Malang, Jawa Timur 65145, Indonesia.
4 Program Studi Pendidikan Matematika, Universitas Negeri Malang, Jl. Semarang No.5, Kota Malang, Jawa Timur 65145, Indonesia

*soleman.saidi@gmail.com

Abstract. This study aims to describe the mistakes of students thinking in solving the problem of Cognitive Reflection Test (CRT) based on dual process theory especially on system 1. The research approach is qualitative by taking the subject as much as 2 students in Senior High School (SMA) 4 Ternate City. The results showed that there are 2 categories of student error in solving mathematical problems using system 1. Where students who solve problems using system 1 but wrong and students who solve problems using system 1 and correct but have no logical reason. The misconception of the students identified is on understanding the concept and modeling of mathematics.

1. Introduction

Thinking process is a mental activity used to help formulate or solve problems, make decisions, and gain understanding [1]. Other than that, consider the thinking process starting from the discovery of information, processing information and conclusions [2]. The thinking process is a process that a person experiences including obtaining information, storing information, and calling back information if needed. Incoming information processed in it, automatically what is already in the brain need adjustment or change altogether. Such a process is called adaptation. Scheffme adaptation can be done in two ways: assimilation or accommodation, depending on the type of information / experience that enters the mental structure [3-5]. Assimilation occurs when the problem structure is encountered in accordance with the existing schema, so that the problem structure can be integrated directly into the existing scheme. While accommodation occurs when the structure of the scheme is not yet in accordance with the problem structure encountered, so need to change the old scheme to fit the problem structure.

Every problem (especially mathematics) faced by students always involves a thought process to solve the problem. Thinking is a cognitive process for transforming information through the interaction between mental attributes such as abstraction, logic and problem solving [6]. The cognitive process referred to is the process of construction or reconstruction of the old knowledge scheme into a new knowledge scheme [7].
In order to construct or reconstruct the old knowledge scheme, information and information processing are required that enable the formation of new knowledge schemes. Information processing in the brain usually occurs in two different ways [8-10], hereinafter referred to as system 1 (intuitive) and system 2 (analysis) in dual process theory [11-13]. System 1 processes information quickly, automatically, or subconsciously (intuition) while system 2 processes information tend to be slow and processes are done consciously (analysis) [11, 12].

Processes performed on system 1 tend to use intuition or confidence alone, but the results tend to be wrong. For some people the results of system 1 are accepted uncritically, in the sense they "behave irrationally" [14], while some people, the result of system 1 is followed by system 2 to provide the necessary adjustments to obtain the correct answer [9, 11, 14]. It seems that in this situation system 1 works very quickly in making decisions based on key features and feelings that are appropriate to a particular situation.

Leron [12] explains that the process of information processing as above needs to be bridged (intervened) student's mindset from system 1 next to system 2 to better understand or solve the problem of mathematics correctly through appropriate analysis steps. The results of the above research have not yet studied about how the thinking process occurs on subjects using system 1 or system 2 in dual process theory, especially the mistakes made when solving the given problem. Therefore, this research focuses more on system 1 in dual process theory by tracing students thinking errors in solving cognitive reflection test (CRT) in order to describe the process of mistakes made by students, more specifically on students who are categorized by using system 1.

2. Method
This research was conducted in second grade of senior high school (SMA) 4 Ternate City by taking 2 students as subject. This study uses a qualitative approach that aims to describe the process of thinking error students who solve the problem of Cognitive Reflection Test (CRT). The selected subjects were the students who solved the problem given using system 1 (intuition) with the steps that is, giving the CRT problem, the students do, then the researcher checks and observes the recording, conducting interviews and other documentation and then analyzed and diekexs data according to research objectives. The focus of the students' error process description in this study focused on the number one of CRT instrument.

3. Result and discussion
Problems given in question number one of CRT as follows: The total price of a stick and the ball is 5,500 IDR, with details stick price 5,000 IDR more expensive than the price of the ball. What is the price of the ball?. The problem solving structure can be described as follows:

![Figure 1. problem solving structure from CRT number one.](image)

Students' work on answer sheets and interviews can be identified as follows: On the question, S1 answered wrong but believes that the answer is correct. This shows that system 1 is more dominant because it processes information faster and relies solely on confidence, in accordance...
with characteristics of system 1 in dual process theory proposed by [11-13]. The process of thinking of undergraduate students in constructing answers can be described as follows:

**Figure 2.** The first subject thought structure in solving problems CRT.

Mistake answer $S_1$ due to lack of information and inconsistency of students' thinking structures with problem structures that exist on the problem. Where the structure of thinking students by looking at the problem on the matter number one just by subtracting the total price of a stick and the ball with stick prices only. Here are the results of work $S_1$.

**Figure 3.** The result of the work of the first subject.

The argument presented by $S_1$ as follows: ,, the price of the stick and the ball the amount of 5,500 IDR, while the price of own stick 5000 IDR, means the total price of the stick and the ball is reduced only with the price of the stick will be the price of the ball 500 IDR.

The information contained in the problem by students is considered as complete information, so the students unknowingly respond as above. The error of the answer by the subject is considered the correct answer on the basis of belief in the information it receives. This is in accordance with the characteristics of system 1. The error of the students' thinking process is due to students assuming the information "stick price of 5000 IDR more expensive" is the total price of a stick. This category of error is a misconception of the concept because the structure of thinking students is not complete when viewed from the structure of problem solving provided. Furthermore from the results of student work and interviews found that $S_1$ difficulties in making mathematical models on the problem, so $S_1$ only use simple algebra operations only.

The second subject ($S_2$) correctly answers the problem of the given problem, but can not provide a logical reason for the answer. According to system 1 on the dual process theory that the student is just guessing or using his or her beliefs alone without providing the steps of completion and logical reasoning. The student answers as follows:

**Figure 4.** The result of the work of the second subject.
After traced the results of student work and interview with the student then identified the student is just guessing the answer, following the results of a brief interview:

P : How is the process so you answer 250 IDR?

S_2 : I just guessed the answer because there are only two things there, namely the stick and the ball.

P : Is there no other reason or another way?

S_2 : no ,, briefly ,, yes ,, I thought it was because the number of both goods is 5,500 IDR the difference must be 500 IDR ,, and because there are two items, then I think the difference is it is divided equally (divided by two) is 500 IDR: 2 = 250 IDR.

Here the structure of second subject thinking (S_2) in answering the matter of CRT:

![Figure 5](image)

Figure 5. the second subject thought structure in solving problems CRT.

Student answers and interview results show that the subject answers the problem by guessing the final answer only, being immediate, immediate or abrupt, using shortcuts, short answers, not detailed, and unable to provide a logical reason or so-called Catalitic Inference in system 1 and it is a characteristic of thinking by using system 1. Just like subject 1, that the second subject error (S_2) because besides not understanding the concept of the given problem, also does not understand how to model the problem into the mathematical model. So the process of answering problem is not complete.

Thus it can be said that both the first subject (S_1) and the second subject (S_2) always use system 1 in solving the given problem. And the student's mistake is more on aspects of concept comprehension, mathematical modeling.

4. Conclusion

This study is identified that both the first subject (S_1) and second subject (S_2) in answering the problems given always use system 1 rather than system 2. Subjects answer the question is direct, guess, immediately or suddenly, using shortcuts, short answers, not detailed, and unable to provide a logical reason or called Catalitic Inference in the process of thinking using the system 1. The student's mistake because it is difficult to understand the concepts and modeling of mathematics that exist on the matter of CRT.

References

[1] Ruggiero V R 2007 Beyond Feelings: A Guide to Critical Thinking by Vincent Ruggiero p 1
[2] Sternberg R J and Sternberg K 2012 Cognitive Psychology 33
[3] Simatwa E M W 2010 Educational Research and Reviews 5(7) pp. 366-371
[4] Mabin V J 2008 International Journal of Operations & Production Management 28(2) pp. 155-184
[5] Mason J, Burton L and Stacey K 2010 Thinking Mathematically p 83-85
[6] Solso R L 2008 Cognitive Psychology 8th edition 345
[7] Tall D 1999 Developments in school mathematics education around the world 4 pp. 117-136
[8] Evans J 2006 Psychonomic Bulletin & Review 13(3) pp. 378-395
[9] Kahneman D and Frederick S 2002 Heuristics and biases: The psychology of intuitive judgment
[10] Evans J St B T and Stanovich K E 2013 Perspectives on Psychological Science 8(3) pp. 223–241
[11] Osman M 2013 A Case Study: Dual-Process Theories of Higher Cognition—Commentary on Evans & Stanovich (England: Queen Mary-University of London)
[12] Leron U 2006 In Two Minds: Dual-Process Theories of Reasoning and Rationality (UK: The Open University and Cambridge 5-7 July)
[13] Wixted T J 2007 Psychological Review 14(1) pp. 152-176
[14] Tzur R 2011 The Mathematics Enthusiast 8(3) pp. 597-636