CRITICAL THINKING PROFILE OF HIGH SCHOOL STUDENTS IN SOLVING WORD PROBLEMS IN THE MATERIALS OF COMPOSITION AND INVERS FUNCTION BASED ON MATHEMATICAL ABILITIES

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Abstract

Many students tend to be trained to do mathematical calculating rather than mathematical thinking. Basicly, mathematical thinking was related to critical thinking, which is a high-level thinking ability. Thus, mathematical problem that suitable for this research is word problem. The materials chosen were composition and invers function because it requires mathematical modeling in solving process that leads students to have critical thinking processes. The purpose of this research is to describe the critical thinking profile of high school students in solving word problems in the materials of composition and invers function based on critical thinking indicators such as clarification, assessment, inference, and strategies that appear in each stage of Polya's problem solving. The type of this research is qualitative descriptive by using test and interview methods. The subjects of this research consist of three students determined by high, medium, and low levels mathematical abilities. The results showed that critical thinking profile of student with high-level mathematical ability was write the answers on the blank paper first. While, student with medium-level mathematical ability was compare the completion between using function and not. Compared with them, student with low-level mathematical ability had many difficulties to through the critical thinking indicators.

Keywords: critical thinking profile, word problems, composition and invers function, mathematical abilities.

INTRODUCTION

In the curriculum in Indonesia today, mathematics becomes one of the subjects with dense hours of study. Based on Ministrial Regulation No. 69 of 2013 *(Permendikbud No. 69 Tahun 2013)* on the Basic Framework and Curriculum Structure of High School in Indonesia, it is known that in one week students will learn mathematics in school for 8 hours of learning consisting of 4 hours of learning for compulsory mathematics and 4 hours of learning for additional mathematics. Unfortunately, the density of lesson hours of mathematical learning that are arranged seems not to be correspond with the learning outcomes, wich one is mathematical ability. Mathematics learning by teachers in the classroom is still too much emphasis on the basic skills, so students tend not to play an active role during learning because the learning process is still teacher-centered (Karim, 2015).

It supports Noyes (2007: 11) that said, "Many children are trained to do mathematical calculations rather than being educated to think mathematically". Noyes believes that many students tend to be trained to do

mathematical calculations rather than being trained to think mathematically. The tendency to only do mathematical calculations often makes students feel bored. This is one of the causes of less actively student's involvement in mathematics learning. If so, then the learning process experienced by students tend to be less meaningful, because in essence that makes a person do a learning process is their involvement when finding the desired knowledge.

Mathematical thinking is basically related to critical thinking. Mathematical thinking is defined as the ability to build reasoning ability and communicate an idea (Leron, 2004). The ability of mathematical thinking is considered to have contributed in developing problem solving skills. According to Resnick (1987), critical thinking is the relationship between high-level reading ability and mathematical thinking. The relationship is an alternative combination and strategy simplification to solve non-routine problems. Meanwhile, according to Ennis (1996: 166), "critical thinking is reasonable reflective thinking focused on deciding what to believe or do". Based on some opinions of these experts, shows the existence of the

relationship between mathematical thinking and critical thinking. Through mathematical thinking, students are trained to have reasoning ability, to express an idea, and to solve problems. While, through critical thinking the students are directed to be able to solve a problem with decision-making based on their beliefs.

Students who think critically will be helpful in solving mathematics problems using mathematical thinking. Conversely, students who are accustomed to think mathematically in solving mathematics problems will tend to have critical thinking. Unfortunately, students' critical thinking abilities in Indonesia are still not satisfactory. This is supported by Wijaya's statement (2012: 1) which says that, *"Hanya 0,1% siswa Indonesia yang mampu mengembangkan dan mengerjakan pemodelan matematika yang menuntut keterampilan berpikir dan penalaran"*. The low student's abilities in making mathematical modeling shows that students have not seen their critical thinking process when faced with a problem that requires mathematical modeling in completion. Therefore, critical thinking seems to need socialized and trained to students in mathematics learning.

In essence, critical thinking is a high-level thinking ability. Setianingsih (2016: 532) said that, *"Keterampilan berpikir kritis dan pemecahan masalah meliputi penggunaan pengetahuan, fakta, dan data untuk memecahkan masalah"*. It means that, in solving a problem, critical thinking and problem solving skills include the use of knowledge, fact, and data. Thus, mathematical problems that are suitable to use in this research is in the form of a word problem, because in its completion requires the ability of thinking that is not simple. According to Fatmawati, et al. (2014), students are able to solve the problem with the calculation and the problem that almost same as the exemplified by teacher, but will be difficult when the form of problems are changed and replaced with word problems. One of the characteristics in solving mathematical word problems is required the mathematical modeling. The aim of this modelling is to create a mathematical model based on the information obtained.

Not all students can easily model the information obtained into the mathematical language (mathematical models). Some can quickly build the mathematical models but some are slow, depending on the problem-solving strategies determined by each student. The strategy is strongly influenced by the mathematical ability. Mathematical ability is a skill in doing or completing mathematics tasks (Soemarmo, 2010). Meanwhile, the meaning of mathematical ability in this study is the intellectual ability of students in mathematics learning. Such that, there will be three categories used in grouping students based on the level of mathematical abilities, including high, medium, and low.

One of the materials that can be made into the word problems is the material of composition and inverse function because it takes mathematical modeling in its completion. Its mathematical modeling leads the students to do the critical thinking process. The process of critical thinking is seen when students try to understand and assess the problem clearly and then connect their knowledge and information obtained to be able in solving the problems.

Based on the background above, the researcher intends to conduct a research entitled "Critical Thinking Profile of High School Students in Solving Word Problems in the Materials of Composition and Inverse Function Based on Mathematical Abilities".

The problems of this research are how critical thinking profile of high school students with high, medium, and low levels mathematical abilities in solving word problems in the materials of composition and inverse function.

METHODS

The research is a descriptive research with qualitative approach, which is to describe critical thinking profile of high school students with high, medium, and low levels mathematical abilities in solving word problems of composition and inverse function materials. This research was conducted to 37 students of class XI-MIPA 2 at SMA Hang Tuah 2 Sidoarjo in even semester of the academic year 2017/2018. There are three students selected who become the research subjects. The complete research procedure is described in the figure below.
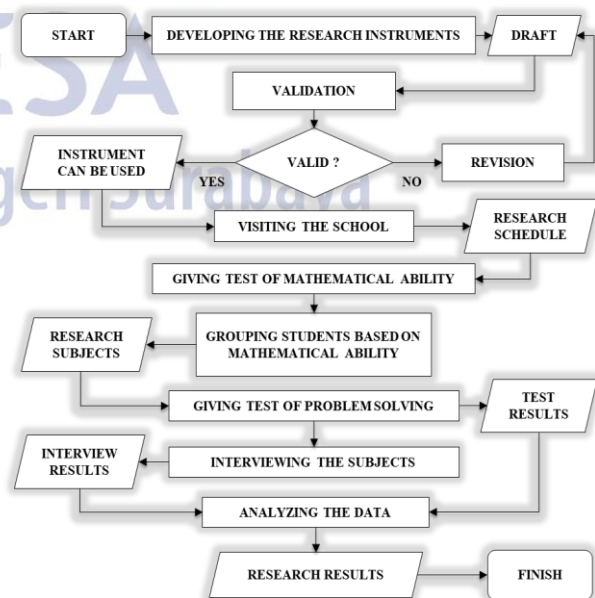

Figure 1. Research Procedures

The instruments that were used in this research consist of:

1. Sheet of Mathematical Ability Test which contains mathematics problems related to composition and inverse function materials.
2. Sheet Solving Problem Test which contains mathematics word problems related to composition and inverse function materials.

Before given to students, both instruments have been checked for its validity through a validation process. Validation was done by two validators consisting of a mathematics lecturer and a mathematics teacher. Specially for solving problems test, there is an additional checking process, namely the legibility test, which is conducted to three students who are in the same education level with the research subjects. Legibility test was done to check whether the order of sentences on the problems can be understood or not.

The research was conducted in three meetings. First, researcher gives Mathematical Ability Test to 37 students of class XI-MIPA 2 at SMA Hang Tuah 2 Sidoarjo to determine three research subjects. Second, the researcher gives Solving Problems Test to three research subjects to obtain written data about student's critical thinking process in. Third, the researcher conducts interview to the three research subjects to obtain oral data about student's critical thinking process.

The analysis of Mathematical Ability Test results guided by Guidelines for Assessment by Educators and Higher Education Units (2017). So the predicate intervals were describe as in the table below.

Table 1. Predicate Intervals Defined in This Research

Predicates	Intervals
A	$91 \leq A \leq 100$
B	$83 \leq B < 91$
C	$75 \leq C < 83$
D	$0 \leq D < 75$

Meanwhile, the criteria used in categorized groups of students based on mathematical ability were as follows.

1. A group of students with high-level mathematical ability is students of grade XI who earn predicate A in Mathematical Ability Test.
2. A group of students with medium-level mathematical ability is students of grade XI who earn predicate B and C in Mathematical Ability Test.
3. A group of students with low-level mathematical ability is students of grade XI who earn predicate D in Mathematical Ability Test.

Three research subjects were obtained by taking each student from a group of students with high, medium, and low- level mathematical ability.

The three subjects were then given Problem Solving Test which contains the mathematics word problems as follows.

1. *Pak Hasan adalah seorang perwira TNI-AL berpangkat Kapten yang akan segera memasuki masa pensiunnya pada bulan depan. Ia ingin mengetahui berapa besar dana pensiun pertama yang akan didapatkan, oleh karena itu ia mencari informasi melalui web* www.asabri.co.id *dan memperoleh rincian sebagai berikut.*

   1. *Penerimaan Kotor:*
      a. *Pensiun Pokok* $= 2,5\% \times$ *Masa Dinas Keprajuritan*
      b. $\times$ *Gaji Pokok Terakhir*
      c. *Tunjangan Istri/Suami* $= 10\% \times$ *Pensiun Pokok*
      d. *Tunjangan Anak (per anak)* $= 2\% \times$ *Pensiun Pokok*
      e. *Tunjangan Beras* $= Rp. 58.050,00$ *per jiwa*
   2. *Potongan*
      a. *Askes* $= 2\% \times ($*Pensiun Pokok* $+$ *Tunjangan Istri* $+$ *Tunjangan Anak*$)$
      b. *Hutang bila ada*
   3. *Penerimaan Bersih*
      Penerimaan Bersih $=$ *Penerimaan Kotor* $-$ *Potongan*

   Gaji pokok terakhir yang diperoleh Pak Hasan sebesar Rp 4.551.700,00 *dan beliau telah mengabdi sebagai prajurit TNI-AL selama 30 tahun. Bila Pak Hasan masih memiliki tanggungan seorang istri dan seorang anak, maka tentukan besar dana pensiun pertama yang akan diperoleh Pak Hasan saat memasuki masa pensiunnya pada bulan depan. Buatlah model matematikanya dan tunjukkan kaitannya dengan fungsi komposisi. (Diketahui bahwa Pak Hasan tidak memiliki hutang sebelumnya)*

   Petunjuk: *Nyatakan besarnya tunjangan istri, tunjangan anak, dan potongan askes sebagai fungsi dalam variabel tertentu.*

2. *Selena yang merupakan Turis asal New York berencana untuk berlibur di Kuala Lumpur dan Jakarta dengan membawa uang sebesar* 2000 *USD. Ia menukarkan seluruh uangnya ke mata uang Ringgit Malaysia (MYR) di Bank Amerika. Kemudian setelah berlibur di Malaysia, ia menukarkan seluruh sisa uang Ringgitnya ke dalam Rupiah (IDR) di Bank Malaysia*

   Harga tukar di Bank Amerika adalah 1 *USD* $=$ 3,99 *MYR, dengan biaya penukaran sebesar* 2 *USD untuk setiap transaksi penukaran. Sementara Harga tukar di Bank Malaysia yaitu* 1 *MYR* $= Rp$ 3.364,76 *dengan biaya penukaran sebesar* 3 *MYR untuk setiap transaksi penukaran.*

   Jika sisa uang yang diperoleh Selena setelah ditukar ke Rupiah (IDR) yaitu sebesar Rp 12.681.847,73 *, maka tentukan besar uang yang dibelanjakan Selena selama di Malaysia. Buatlah model matematikanya dan tunjukkan kaitannya dengan fungsi komposisi dan fungsi invers.*

   Petunjuk: *Nyatakan besarnya harga tukar yang berlaku di setiap bank sebagai fungsi dalam variabel tertentu.*

The analysis of Problem Solving Test and interview results was guided by the critical thinking indicators adapted from Jacob and Sam (2008) and correspond to the Polya's problem solving stages. The critical thinking indicators used in this research were as follows.

Table 2. Critical Thinking Indikators in Polya's ProblimSolving Stages

Problem Solving Stages	Critical Thinking Indicators	Criterias
Understanding the Problem	Clarification	a. Identifying the scope of the problem. b. Determining the infor-mation that is known and asked.
Devising a Plan	Assessment	c. Collecting the relevant informations. d. Determining the relation-ship between the informa-tions obtained . e. Giving the relevant reasons.
	Inference	f. Determining the steps to solve the problems.
	Strategies	g. Discussing the other steps that might be used to solve the problems.
Carrying out the Plan	Inference	h. Completing the problem by using the informations that have been collect and the steps that had been made. i. Drawing conclusion based on the steps that have been used.
Looking Back	Strategies	j. Evaluating the steps that have been used in solving the problem.

Adapted from Jacob and Sam (2008)

RESEARCH RESULTS AND DISCUSSIONS

This research was done in one class of XI MIPA 2 at SMA Hang Tuah 2 Sidoarjo on 6th - 10th of March, 2018. On 6th of March, 2018, students were given Mathematical Ability Test of composition and inverse function materials in one hour and half long to get the research subjects. On 7th of March, 2018, three students were given Legibility Test to check whether the order of sentences on the problems can be understood or not. On 8th of March, 2018, students were given Problem Solving Test of composition and inverse function materials in the form of word problems for one hour long. On 10th of March, 2018, students were interviewed to gain the oral information about student's critical thinking process in solving the word problems.

Based on scores obtained by students at Mathematical Ability Test, students are divided into groups of high, medium, and low levels mathematical abilities. There are 2 students with high-level, 15 students with medium-level, and 20 students with low-level mathematical abilities. Research subjects was gotten by selecting one student from each group based on recommendation given by the teacher in order to obtain a communicative subjects, such that its easier to gather the informations about student's critical thinking profile. Details of research subjects can be seen in Table 3.

Table 3. Research Subjects

No.	Name	Score	Predicate	Mathematical Ability Levels	Code
1.	SMA	92	A	High – level	ST
2.	AAB	85	B	Medium – level	SS
3.	MBRB	40	D	Low -level	SR

1. Data Analysis and Discussion about Solving Problem Test and Interview Results of Student with High-Level Mathematical Ability (ST)

The results of ST's Problem Solving Test are presented in Figure 2 and Figure 3, and the analysis of its data is presented below the figures.

Figure 2. ST's Answer of 1st Problem

Based on the result above and interview, the critical thinking profile of ST in solving 1st problem, can be seen as follows. In the stage of understanding the problem, in clarification student identifies the

scope of the problem and determines the informations that are known and asked from the question.

In the stage of devising a plan, in assessment student collects the relevant informations, determines the relationship between the information obtained, and explains the reasons. In inference student determines the steps to solve the word problems such as read the problem carefully and write the answer first on the blank paper. While in solving the problem, student determines the completion steps that are related to composition function. In strategies, student suggests the other step that can be used, such as write the answers directly on the worksheets without write it on the blank paper first. While in solving the problems, student thinks open mindedly so that she can finds the other step that is by manual or without modeling it into the form of function, and student is able to explain each step well.

In the stage of carrying out the plan, in inference student solves the problem by using the informations that have been collected and using the steps that have been made. Moreover, student draws the correct conclusion based on the steps that have been used. In addition, student can also shows the use of composition function in her work.

In the stage of looking back, in strategies, student evaluates the steps that have been used. In checking her work, student checks the fomulas and calculations that have been used.

Figure 3. ST's Answer of 2nd Problem

Based on the result above and interview, the critical thinking profile of ST in solving 2nd problem looks similar with her critical thinking profile in solving 1st problem. The differences only can be seen in inferences in the stage of devising a plan and carrying out the plan because she is not only describe about the steps that are related to the use of composition function but also involve the use of inverse function.

2. Data Analysis and Discussion about Solving Problem Test and Interview Results of Student with Medium-Level Mathematical Ability (SS)

The results of SS's Problem Solving Test are presented in Figure 4 and Figure 5, and the analysis of its data is presented below the figures.

Figure 4. SS's Answer of 1st Problem

Based on the result above and interview, the critical thinking profile of SS in solving 1st problem, can be seen as follows. In the stage of understanding the problem, in clarification student can identifies the scope of the problem well and determines the informations that are knaown and asked.

In the stage of devising a plan, in assessment student collects the relevants information, determines the relationship between the informations, and gives the relevant reasons. In inference, student determines the steps to solve the word problems such as read the problem carefully, write down the information that is known from the problem and try to modelling the information obtained into the form of composition function. While in solving the problems, student determines the completion steps that have been made. The steps are related to composition function. In strategies, student suggests the other step that can be used, that is by manual. He thinks open mindedly so

that he can finds the other step that is by not changing the information into the form of functions, but it can be done directly by using the information obtained.

In the stage of carrying out the plan, in inference student solves the problem by using the the informations that have been collected and using the steps that have been made. Moreover, student draws the correct conclusion based on the steps that have been used. In addition, student can also shows the use of composition function in his work.

In the stage of looking back, in strategies student evaluates the steps that have been used by re-read the problem, re-calculate the doubtful part, and then compare the results between using function and not.
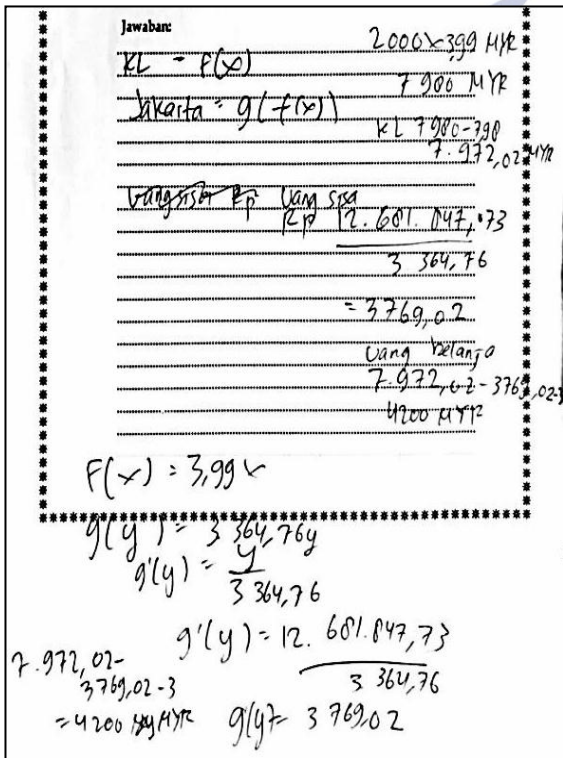

Figure 5. SS's Answer of 2nd Problem

Based on the result above and interview, the critical thinking profile of SS in solving 2nd problem looks similar with his critical thinking profile in solving 1st problem. The differences can be seen from the clarification in the stage of understanding the problem and the inferences in the stage of devising a plan and carrying out the plan. In the stage of understanding the problem, in clarification student has a little mistake in expressing the problem. While in determining the informations that are known and asked, student is able to explain it well. Moreover, in inferences in the stages of devising a plan and carrying out the plan, student is not only describe about the steps that are related to the use of

composition function but also involve the use of inverse function.

3. Data Analysis and Discussion about Solving Problem Test and Interview Results of Student with Low-Level Mathematical Ability (SR)

The results of ST's Problem Solving Test are presented in Figure 6 and Figure 7, and the analysis of its data is presented below the figure.
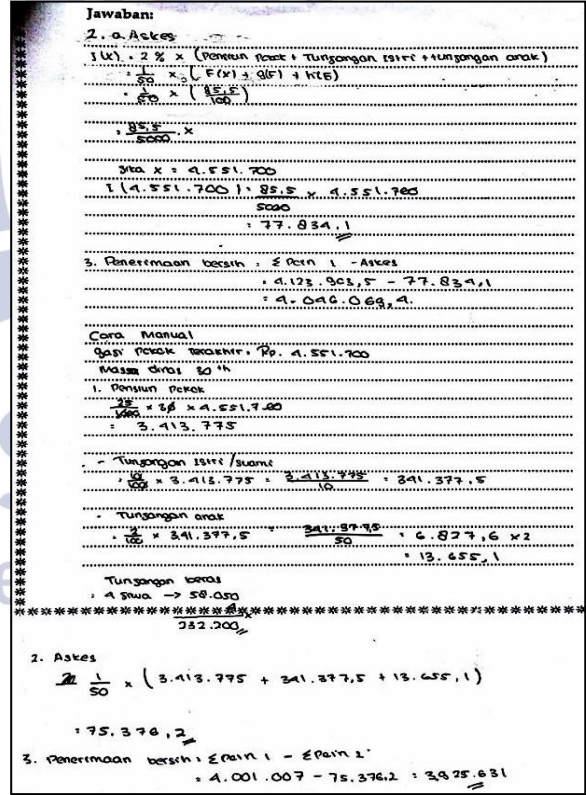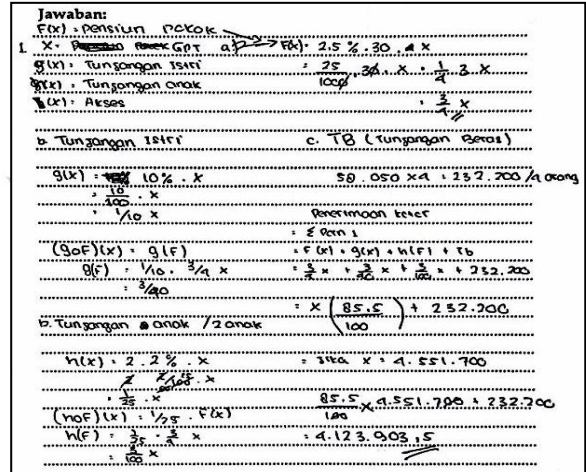

Figure 6. SR's Answer of 1st Problem

Based on the result above and interview, the critical thinking profile of SR in solving 1st problem, can be seen as follows. In the stage of understanding the problem, in clarification student can identifies the scope of the problem well, but has a little mistake in mentioning the known information.

In the stage of devising a plan, in assessment student collects the relevant informations and suggests that there is relationship between the informations, but he can not explain the reasons. In inference student determines the steps to solve the word problems such as read the problem, finds the known, answering the question by using composition and inverse functions. While in solving the problems, student explains each step that had been made to solve the problem. The steps are related to the use of composition function. In strategies student thinks open mindedly so that he can explains the other step that can be used is manual or by calculating without modeling the information into the form of functions.

In the stage of carrying out the plan, in inference student solves the problem by using the steps that have been made but he can not draw the correct conclusion because he is not aware that there is a wrong information on his completion.

In the stage of looking back, in strategies student evaluates the steps that have been used by re-read the problems. Unfortunately, even though he has re-read the problem, but he can not find the mistake in his completion.

Figure 7. SR's Answer of 2nd Problem

Based on the result above and interview, the critical thinking profile of SR in solving 2nd problem, can be seen as follows. In the stage of understanding the problem, in clarification student has difficulties in understanding the problems so he can not determine the information that is known and asked well.

In the stage of devising a plan, in assessment student feels not sure when expressing the relevant informations because he had so many difficulties in understanding the scope of the problems. In inference student determines the steps to solve the word problems such as read the problem, finds the known, answering the question by using composition and inverse functions. While in solving the problems, student explains each step that had been made to solve the problem. But student does not explain the complete step because he has not finished the completion. In strategies student thinks open mindedly so that he can explains the other step that

can be used is manual or by calculating without modeling the information into the form of functions. But student feels not sure with his explanations because he did not fully understand about the scope of the problem.

In the stage of carrying out the plan, in inference student solves the problem by using the steps that have been made but still has some errors in his completion.

In the stage of looking back, in strategies student evaluates the steps that have been used by re-read the problems. Unfortunately, even though he read the problem over and over, but he still can not gain the clarity, and he feels more confusion about it.

CLOSURE
Conclusion

Based on the data analysis and discussion, the researcher draw conclusions about the critical thinking profiles of students with high, medium, and low levels mathematical abilities in solving the word problems in the materials of composition and inverse function as follows. The critical thinking profiles of students with high and medium levels mathematical abilities are able to through all of critical thinking indicators. The activity that showed the critical thinking profile of student with high-level mathematical ability was write the answers on the blank paper first. While, student with medium-level mathematical ability was compare the completion between using function and not. Compared with them, student with low-level mathematical ability had many difficulties to through the critical thinking indicators when completing the problems.

Suggestions
1. For teachers should be able to create mathematics learning which often provides questions that can develop student's critical thinking skills by notice the level of student's mathematical ability. If it is possible, give more attention to students with low-level mathematical ability because based on the research results, it appears that there are still many critical thinking indicators that can not be through by the student. Thus, students are expected to improve their critical thinking skills.
2. For researchers who want to conduct relevant research.
   a. Should be possible to provide clear instructions to the students during the test, as in this research that using a test in the form of a word problem, it is better if the researcher gives the initial instruction to students to write "known", "asked", and

"answer" in their work to facilitate the researcher when analyzing student's work results.

b. Should be more attention to the student's work results when the interviewing process so that researcher can describe more clearly about the students's critical thinking profile in solving word problems of composition and inverse functions based on student's mathematical ability.

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