Error Analysis of Trigonometric Problem Solving by Vocational High School Students Based on Differences in Ability and Cognitive Style

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Abstract: The purpose of this study was to describe the locations, types and contributing factors of the students of mechanical Vocational High Schools in solving trigonometry problems. This was descriptive research. The research was conducted in three vocational high schools. The main instrument in this research was the researcher himself. Other instruments used in the research were test of mathematical ability (TOMA), The Group Embedded Figures Test (GEFT), trigonometry problem solving tasks and interview guides. The research data were analyzed in four stages, namely: data categorization, data reduction, data presentation, conclusion drawing. The results obtained by discovering the locations, types, and contributing factors of the students' errors could reveal whether or not the learning that had been implemented in accordance with the goals to be achieved. By doing the analysis of the students' errors, the appropriate learning model to improve their understanding of trigonometric problem solving in particular and improve the mathematic learning outcomes in general is therefore recommended.

1 INTRODUCTION

Mathematical problem solving has become the center of attention in 2013 curriculum recentnly (Kemendikdub, 2014; Depdikbud, 2016). Many Indonesian children have difficulty in solving mathematical problems (Tatag, Y.E.S., et al., 2015). Based on the result of preliminary study conducted by researchers at 3 mechanical vacational high school in East Java Indonesia, was that only 15% of students able to solve mathematical problems especially trigonometry well. To overcome these problems and to find out the reasons that cause low understanding of trigonometric problem solving , It is necessary to analyze the mistakes made by mechanical vacational high school student.

Some studies have shown that cognitive style is a very important thing in learning (Acharya, 2002; Tenant, 1988; Kagan, 1966; Egelan, 1974; Witkin, et al., 1977; Witkin, et al., 1971; Tantiana, A. G., Iriana, A. L., 2014). By knowing the cognitive style of learners, teacher can use appropriate method in teaching mathematical concepts, especially trigonometry for those who have a particular cognitive style. The cognitive style used in this study is the cognitive style of Field dependent and Field independent.

Students with a field dependent cognitive style are difficult to separate items of an object from their original form (Witkin, et al., 1971; Slameto, 2003). Students with independent field cognitive style are students who are able to abstract elements from their context, they tend to be more analytic and tend to use problem-solving approaches in a more analytic way (Witkin, et al., 1977; Slameto, 2003).

Witkin, et al. (1971) states that, cognitive style is a characteristic reflected from each individual and these characteristics can be influenced by two factors, namely: factors related to the influence of external stimuli and individual personal influences. The external stimulus factors is the dominant enough to affect psychiatric problems, such as educational environment, family environment, and community environment.

Besides the cognitive styles, the different aspects of students' abilities influences the mathematical problem-solving abilities (Astunnisyah, Budiono, Isnandar, S., 2017; Sukriadi, A., Juniati, D., Tatag, Y.E.S., 2017; Utomo, E.S., Juniati, D., Tatag, Y.E.S., 2017). Problem solving is defined as an attempt to find out solution of difficult probme to achieve goals

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(Polya, 1973). While Cooney et al. (1975) suggested that problem solving as a process of accepting problems and trying to solve the problem. Problem solving is form of a mental activity consisting of various cognitive skills and actions intended to obtain the correct solution (Kirkley, 2003). Thus, the solution of the problem among individual is different.

The stages of problem solving in this study refers to Polya's opinion (1973). Polya's problem-solving steps are from (1) understanding the problem, (2) making problem-solving plan, (3) implementing problem solving plan, (4) reviewing problem solving result. While the aspect of ability selected from students who have high, medium, and low ability.

The reasons why students feel difficult to solve trigonometry problem can be reviewed from students' method in solving trigometry problems. Therefore, it is important to make an error analysis of students in solving the trigonometry problem. The errors of Students that are analyzed include (Polya, 1973) the location, the type (Soedjadi, 2000), and the error influencing factor. After knowing the location, type, and error influencing factors made students in solving trigonometry problem, the alternative solution can be determined. Thus, it is expected that by analyzing students' error we can improve their understanding of trigonometric problem solving in particular and improve their mathematics learning outcomes in general.

2 RESEARCH METHOD

The design of this study used descriptive research to describe the location, type and error influencing factors of student in solving the trigometry problems. While the approach used in this study is a qualitative approach because the data collected and presented in the form of words that are arranged in a sentence, rather than a number or value.

The subjects of this study were students with high ability and field dependent and field independent cognitive style, and students with moderate ability of field dependent and field independent cognitive style, and students with low ability of field dependent and field independent cognitive style.

In addition to the researcher as the main instrument, other instruments are needed as well such as test of mathematical ability (TOMA) instruments, problem-solving tasks, The Group Embedded Figures Test (GEFT), and interview guidelines. The data were collected using tests and interviews to determine the location, type, and error influencing factors made by the subject of research. The location of the error viewed from the mistake made by the subject while solving problem in using Polya's steps. The type of error refers to instruments made by Sudjadi (2000), for instance ; factual errors, concepts, operations, and principles. Error influencing Factor relates to internal factors. Data analysis started from the preparation of the research to the completed data collection process. In this research, data analysis technique is done through 4 stages, namely: data categorization, data reduction, data presentation, conclusion drawing

3 RESULTS AND DISCUSSION

3.1 Results

The Subjects of this research are Students of mechanical vocational high school in East Java Indonesia, selected using test of mathematical ability (TOMA). The result of test is the form of score and then is categorize as high ability (if their score is > 87), categorized as moderate ability (if their score is more than 67 and less than 87), and categorized as low ability (if their score is below 67).

The next step is giving the selected students a test of mathematical ability (TOMA). The results of GEFT results are assessed based on the guidelines developed by Witkin, ie students who get score between 0-9 in sections 2 and 3 are classified into the field dependent (FD) cognitive style while students who get score between 10-18 is classified in the field independent (FI) cognitive style.

To determine the subject of study needs to be tested using GEFT for 3 times, so that the selected subject is really in accordance with the cognitive style. Based on the distribution of mathematics ability, cognitive style, teacher's consideration, and score of their learning report, so that the 6 subjects are categorized as high, moderate, and low ability and field dependent (FD) and field independent (FI) cognitive style.

To determine the location, type, and error influencing factors in solving the trigonometry problem conducted subjects is based on differences in ability and cognitive style in general is found in all stages beginning at understanding the problem, planning the problem-solving, solving the problem, reviewing the result of problem solving.

3.2 Discussions

Based on the analysis and the results of the research, the location of the errors of students with low ability

and field dependent cognitive style in solving mathematical trigonometry problem is found in all stages beginning at understanding the problem, planning the problem-solving, solving the problem, reviewing the result of problem solving. While the type of error that students with low ability and Field Dependent cognitive style is all kinds of errors ranging from fact, concept, opration, and principle errors that spread at all stages of problem solving. While error influencing factor in general are internal factors caused by the intellectual ability, and the cognitive conditions of the subject.

The error location of students with low ability and field independent cognitive style in solving mathematical trigonometry problem is found in all steps: beginning at understanding the problem, planning the problem-solving, solving the problem, reviewing the result of problem solving. The type of error that subjects with low ability and *Field Independent* cognitive style is type of factual error and principles at all stages of problem solving. While error influencing factors in general are internal factors caused by the intellectual ability, and the cognitive conditions of the subject.

If compared between subjects with low ability and field dependent cognitive style and subjects with the low ability and Field independent cognitive, both of them have similarity and differences. The similarity is that both of them make mistakes at all stages of problem solving. While the difference is subjects with low ability and Field Independent cognitive style only do 2 types of errors, but subjects with low ability and Field dependent cognitive style make 4 types of errors at once.

Error location of subjects with moderate ability and Field Dependent cognitive style in solving mathematical trigonometry problem is found in all stages beginning at understanding the problem, planning the problem-solving, solving the problem, reviewing the result of problem solving. While the types of mistakes made by subjects with moderate ability and Field Dependent cognitive style are all types of errors ranging from factual errors, concepts, operations, and principles that spread at all stages of problem solving. While the error influencing factors in general are internal factor caused by the intellectual ability, and the cognitive conditions of the subject.

The error location of subjects with moderate ability and Field Independent cognitive style in solving mathematical trigonometry problem is found in three stages beginning at, planning the problem-solving, solving the problem, reviewing the result of problem solving. Subjects with moderate Field Independent cognitive style do not make mistakes (error) at understanding problem stage. The types of mistakes made by subjects with moderate Field Independent cognitive style are all types of errors ranging from error concepts, and principles that spread at all stages of problem solving. While the error influencing factors in general are internal factors caused by the intellectual ability, and the cognitive conditions of the subject.

If compared between subject with moderate ability and Field Dependent cognitive style and subject with moderate ability and Field independent cognitive have difference in location and types of error made by them. The error of location that is conducted by subject with moderate ability and Field Independent cognitive style is located in three steps of planning the problem solving, implementing the problem solving and reviewing the problem solving result. While The error of location that is conducted by subject with moderate ability and Field Dependent cognitive style is located in all steps, beginning from understanding the problem, planning the problem solving, implementing the problem solving and reviewing the problem solving result.

While the type of error made by subject with moderate ability and Field Dependent cognitive style are all types of errors such as factual error, concepts, operation, and principles. These types of errors spread at all stages in problem solving. And 2 types of errors made by subject with moderate ability and Field Independent cognitive style that are concept and principle errors that spread only at each stage of problem solving except the stage of understanding the problem.

The error location of subject with high ability and field dependent cognitive style in solving mathematical trigonometry problem is found 3 steps: beginning at planning the problem-solving, solving the problem, reviewing the result of problem solving. The type of error that subjects with high ability and *Field Independent* cognitive style is error principles spread in stages of problem solving such as planning the problem solving, implementing the problem solving and reviewing the result of problem solving.While error influencing factors in general are internal factors caused by the intellectual ability, and the cognitive conditions of the subject.

The subject with High ability and Field Independent cognitive style do not make mistakes in all steps of problem solving. The error influencing factor in general are internal factors caused by high intellectual ability, and cognitive conditions of the Subject.

If compared between subject with high ability and Field Dependent cognitive style and subjects with

high ability and Field independent cognitive style has differences in the location and type of errors that are made by them. The error location of subject with high ability and Field Dependent cognitive style is found in 3 steps: that are at planning the problem solving, implementing a problem-solving, and reviewing the results of problem-solving. While subjects with high ability and Field independent cognitive style do not make errors in solving the trigonometry problems.

Based on the results, analysis, and discussion of research, it can be found that the cognitive style influences the process and the results of trigonometry problem solving of subjects with low, medium, and high ability. The subject with Dependent cognitive style make more mistakes (both error location and types of error), than subject with Independent cognitive style. This is in line with the results of research conducted by Andi sukriani, edy, and astunisyah that the cognitive styles (FI and FD) possessed by high school students influence the results of mathematical problem solving (Astunnisyah, Budiono, Isnandar, S., 2017; Sukriadi, A., Juniati, D., Tatag, Y.E.S., 2017; Utomo, E.S., Juniati, D., Tatag, Y.E.S., 2017). But in the study they did not see the location, type, and factors that influence the mistakes made by students in solving mathematical problems.

4 CONCLUSIONS

The error location of the errors in solving mathematical trigonometry problem by students with low ability and field dependent-field independent cognitive style is found in all stages beginning from understanding the problem, planning the problem-solving, solving the problem, and reviewing the result of problem solving. While the error type of students with low ability and Field Dependent cognitive style is all kinds of errors ranging from fact, concept, opration, and principle errors that spread at all stages of problem solving. The error type of subjects with low ability and *Field Independent*cognitive style is type of factual error and principle at all stages of problem solving.

Error location in solving mathematical trigonometry problem of subjects with moderate ability and Field Dependent cognitive style is found in all stages. While the types of mistakes made by subjects with moderate ability and Field Dependent cognitive style are all types of errors ranging. The location of the errorsof subjects with moderate ability and Field Independent cognitive style in solving mathematical trigonometry problem is found in three stages, such as planning the problem-solving, solving the problem, reviewing the result of problem solving. Subjects with moderate Field Independent cognitive style do not make mistakes (error) in understanding problem stage. The types of mistakes made by subjects with moderate Field Independent cognitive style are all types of errors ranging.

The error location of subject with high ability and field dependent cognitive style in solving mathematical trigonometry problem is found 3 steps: beginning at planning the problem-solving, solving the problem, reviewing the result of problem solving. The error type of subjects with high ability and *Field Independent* cognitive style is error principles spread in stages of problem solving such as planning the problem solving, implementing the problem solving and reviewing the result of problem solving. The subject with high ability and Field Independent cognitive style do not make mistakes in all steps of problem solving.

While error influencing factors made by students with high, moderate, and low ability and Field Dependent or Field Independent cognitivestyle in general is an internal factor caused by intellectual ability, and the cognitive conditions of the Subject.

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