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# Mathematics Problem Solving Analysis on Higher Order Thinking Skills Based on Story Questions

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ABSTRACT

This study aims to determine the problem-solving ability of field independent (FI) and field dependent (FD) students in solving HOTS story problems. This type of research is qualitative research. The research strategy used is a descriptive model. This research was carried out at a junior school in Malang, Indonesia. The respondent was tenth-grade students. Data collection methods in this study include tests and interviews. Data analysis techniques include data collection, reduction, presentation, and concluding. The results of this study show that FI and FD students understand the problem. There is no difference between the two; FI and FD students are good at understanding the problem. FI students plan solutions well and can correctly create mathematical models, while FD students have difficulty developing mathematical models. In getting answers, FI and FD students have something in common: they are not quite right in the final solution.



## Introduction

Problem-solving is a process that begins with the initial contact with the problem and ends when the answer is received based on the information provided [1]. Meanwhile, according to Ref. [2], problem-solving is one of the foundations of teaching mathematics.

Problem-solving is not a separate subject in mathematics but a topic that requires integration with all mathematical issues [2]. Ref. [3] mentions that problem-solving is essential to intelligence. Problem-solving can be understood as an important characteristic of humans and can be learned by imitating or experimenting. Problem-solving is also an activity that involves various actions in mind, including using knowledge and experience [4].

Problem-solving is essential in mathematics education because it can train students to think mathematically [5]. In solving mathematical problems, students must understand the mathematical concepts learned and apply them to solving problems [6]. Solving problems requires not only mathematical knowledge but also an understanding of the situations posed by the text since the problem reflects real-world situations [7]. Problem-solving in mathematics is usually in the form of story problems [7].

According to [8], the problem of stories is the primary mechanism by which school-based mathematics is connected with actions and events in everyday and professional life. The issue of the story requires not only the ability to calculate but also the ability to reason and understand the problem [7]. Problems in story questions also contribute to allowing students to transfer the knowledge and traditional math skills they learned at school into their real lives [2]. Difficulties are also experienced by many students in solving problems related to story problems [8].

Problem-solving is one of the teaching strategies that developed *Higher Order Thinking Skills* (HOTS) [4]. Higher order thinking skills (HOTS) are one of the components of creative thinking and critical thinking skills [9]. HOTS includes skills such as creative thinking, critical analysis, problem-solving and visualization [10]. HOTS allows students to become more independent and resourceful learners, proficient in problem-solving and able to use scientific content in everyday contexts [11]. To develop students' understanding of HOTS questions, students must engage with learning tasks that exceed the second level of 'understanding' to encourage application, analysis, synthesis and evaluation activities in processing information [12].

Human thinking skills can be classified into two large groups; lower order thinking skills (LOTS) and higher order thinking skills (HOTS) [13][14]. LOTS is the first three aspects of Bloom's Taxonomy, namely: remembering (C1), understanding (C2), and applying (C3), while the following three levels, namely: analyzing (C4), evaluating (C5), and creating/creating (C6) are hots types [14][15]. Implementing HOTS in teaching and learning mathematics is crucial to changing society's stigma on mathematical difficulties [13].

Resnick [11] suggests some common characteristics of high-level thinking: a double solution that is not algorithmic, complex generates a key and requires the application of several criteria. HOTS brought about a fundamental change in evaluation reforms aimed at promoting thinking skills in learners and taking them away from memorization of learning [10]. The Ministry of Education (MOE) states that HOTS is the ability to create new dimensions based on the knowledge that has been learned and apply knowledge or methods to solve problems creatively, innovatively and consequently [4]. Implementing HOTS in teaching and learning mathematics is essential to change society's stigma on mathematical difficulties [4].

One of the problem-solving strategies that can be used is the Polya strategy [3]. Polya [16] claims that new knowledge in mathematics can be obtained by considering the related problems, and using our previous knowledge, reinvention is the primary tool for materialization from Piaget's perspective. George Polya [17] goes through four phases, providing one heuristic to solve problems that can help students become more successful problem solvers. The four phases are understanding the problem, planning the strategy, implementing the plan and re-checking [17]. Ref. [1] found that problem-solving according to Polya was preferred over Gick, Bransford, and Stein's problem-solving model.

Cognitive styles are potential variables in learning and academic development that affect students' thinking [18]. Cognitive style is how students think about what they are learning [19]. Ref. [20] defines cognitive styles as relatively stable strategies, preferences, and attitudes that determine an individual's distinctive way of understanding, remembering, and solving problems. Cognitive styles are essential to improving student mathematics achievement [21]. Cognitive styles are divided into two, namely field independent (FI) and field dependent (FD) [22]. FI students tend to be more analytical and better able to restructure aspects of abstract problems compared to FD students, who have social skills, attitudes, perceptions and qualities strongly influenced by their physical and social background [23]. Students with the FD type have difficulty in organizing new information and relating it to the previous one, as well as having difficulty in retrieving data from long-term memory [24].

Several studies have been conducted on the analysis of mathematical problem-solving ability. Research on the analysis of mathematical problem-solving skills related to Polya has already been carried out [25]. Analysis of mathematical problem-solving skills associated with HOTS has also been carried out [26]. However, the study of solving mathematical problems in the form of HOTS story problems in students' cognitive styles has not been carried out. It is distinguished from previous studies is the story problems in the form of HOTS and reviewed from their cognitive style.

Based on the description above, students' problem-solving ability of both FI and FD types in solving HOTS story problems is exciting, so researchers study more about student problem-solving. It is hoped that teachers can use the results of this study to provide appropriate assistance to FI-type and FD-type students in solving HOTS story questions. Based on the background above, the formulation of the problems in this study is:

1) How is the problem-solving ability of FI and FD type students in solving HOTS story problems?
2) Is there a difference in the math problem-solving ability of FI and FD students in solving HOTS story problems?

## Method

This type of research is qualitative research. The research strategy used is a descriptive model. This research was carried out at a junior school in Malang, Indonesia. The subjects in this study were tenth-grade students. The study subjects' determination is based on the GEFT (Group Embedded Figure Test) results. From the results of the GEFT test, data were obtained regarding the types of cognitive styles of students, which include field-dependent cognitive techniques and field-independent cognitive styles. So, the subjects in this study were two groups, namely FD cognitive-style students and FI students. Researchers then gift tests to the 28 students who attended, who had previously gone through a validation process. The validity aspects used are the material, sentence construct, language, and validity of hots questions. The validators in this study are three lecturers of master of mathematics education and two mathematics teachers in junior high schools. After the GEFT test was carried out, it was obtained that students with the FI cognitive style type were 16, while the FD type was 14. After that, the researcher gave a test of HOTS questions, which had previously also been validated.

Data collection methods in this study include test methods and interviews. There are two types of tests used in this study: the GEFT test to determine the category of cognitive styles possessed by students and the description test in the form of HOTS story questions to assess students' problem-solving abilities. The interview data collected is a statement about the things students do in completing the test questions and the difficulties experienced by students.

Data analysis techniques in this study use the following interactive methods: data collection, data reduction, data presentation, and conclusions or verification.

**Table 1.** Troubleshooting rubric

| | | |
|---|---|---|
| Problem Understanding | 2 | Thoroughly understand the problem |
| | 1 | Understanding the problem less precisely. |
| | 0 | Misunderstanding the problem |
| Planning a Solution | 2 | Can lead to the correct resolution if applied correctly |
| | 1 | Partly true based on the part of the problem that is interpreted correctly |
| | 0 | No effort or wrong |
| Getting Answers | 2 | Correct answer |
| | 1 | Copy errors, computational errors, and partial answers are correct. |

| | |
|---|---|
| 0 | No wrong answer or answer based on an improper plan |

Source: [27]

## Results and Discussion

### A. Normality Test

This normality test is used to see whether the variables that have been selected in the regression model have a normal distribution or not. The results of this normality test will be said to be expected if the significant value of the variables > 0.05. The normality test is shown in Table 2.

**Table 2.** Normality test

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistics | Df | Sig. | Statistics | Df | Sig. |
| FI Learning Outcomes | .179 | 14 | .200* | .960 | 14 | .720 |
| FD Learning Outcomes | .195 | 14 | .157 | .897 | 14 | .103 |

Based on Table 2, the sig value. Shapiro-Wilk for FI student learning outcomes is so that FI learning outcomes data are normally distributed. Next is the sig value. The FD learning outcomes data are also normally distributed for FD learning outcomes. The normality test results of FI and FD learning outcomes are normal.

### B. Homogeneity Test

Homogeneity tests are carried out to determine whether the sample is used in homogeneous research. If this is met, it can be continued for the next stage. The homogeneity test data used are data on the learning outcomes of FI and FD students. A distribution is said to be homogeneous if the significance level is higher than 0.05, while the significance level lower than 0.05 is inhomogeneous. The results of data homogeneity are presented in Table 3.

Based on Table 3, it is known the sig value. If the mean is as large, then it can be interpreted that the data variance between FI and FD students is homogeneous or the same so that the interpretation of the independent samples test is guided by the value of the equal variance assumed.

**Table 3.** Homogeneity Test of Variances

| | | Levene Statistics | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Learning Outcomes | Based on Mean | .018 | 1 | 28 | .895 |
| | Based on Median | .013 | 1 | 28 | .910 |
| | Based on Median and with adjusted df | .013 | 1 | 25.034 | .910 |
| | Based on trimmed mean | .033 | 1 | 28 | .857 |

## C. Test of The Difference Between Two Groups

It was carried out by testing the differences in the difference data in the two groups to see the difference in the learning outcomes of FI and FD students. In this case, it was carried out with an independent sample test. This Independent Sample T-test decides whether the research hypothesis is accepted or rejected. If the probability value (p) is higher than 0.05, then $H_0$ is accepted; otherwise, If the probability value (p) is lower than 0.05, $H_0$ is rejected. See Table 4 for the results of the Independent Sample T-test.

**Table 4.** Independent Samples Test

| | | Leven's Test for Equality of Variances | | | | | t-test for Equality of Means | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | T | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Hasil Belajar | Equal variances assumed | .018 | .895 | 2.992 | 28 | .006 | 4.00893 | 1.33994 | 1.26419 | 6.75367 |
| | Equal variances not assumed | | | 3,024 | 27.990 | .005 | 4.00893 | 1.32557 | 1.29358 | 6.72428 |

Based on Table 4, the sig (2-tailed) value of 0.006 is lower than 0.05; then, as the basis for decision-making in the independent sample t-test, it can be concluded that Ho was rejected and Ha was accepted. Thus it can be supposed that there is a significant difference between the COGNITIVE style of FI and the cognitive style of FD in solving problems. It is under the results of research by [28] that the problem-solving ability possessed by FI students is different from that of FD students. Furthermore, in table 4, it is known that the mean difference value is 4.00893. This score shows the difference between the average problem-solving results in FI students and FD students, and the difference between those differences is 1.26419 to 6.75367.

## D. Problem Solving Analysis in FI Students

In FI students, the four stages of problem-solving of hots story problems in the Polya method based on Table 1 are correct, although some are not quite right. The following explains each step of solving the problem for FI students. At this stage of problem understanding, at this stage, FI students can understand what is meant by HOTS questions; this can be seen from the answers of FI students, namely being able to write down what is known and asked correctly. During the interview, if students explained that students could understand the questions and know what was requested from the questions. FI students have also determined the completion model to solve HOTS problems in planning solutions. During the interview, FI students admitted that they already knew the settlement model that must be made to solve this problem.

Furthermore, at the stage of getting answers, FI students have difficulties; students are not suitable in taking the conclusion of the solutions, which results in FI students getting the final answer incorrectly. FI students are only less careful in making the final decision. When interviewed, FI students did not know that they had made a mistake in calculations; students felt that they had gotten the definitive answer correctly. The results of the fi student's work can be seen in Figure 1.

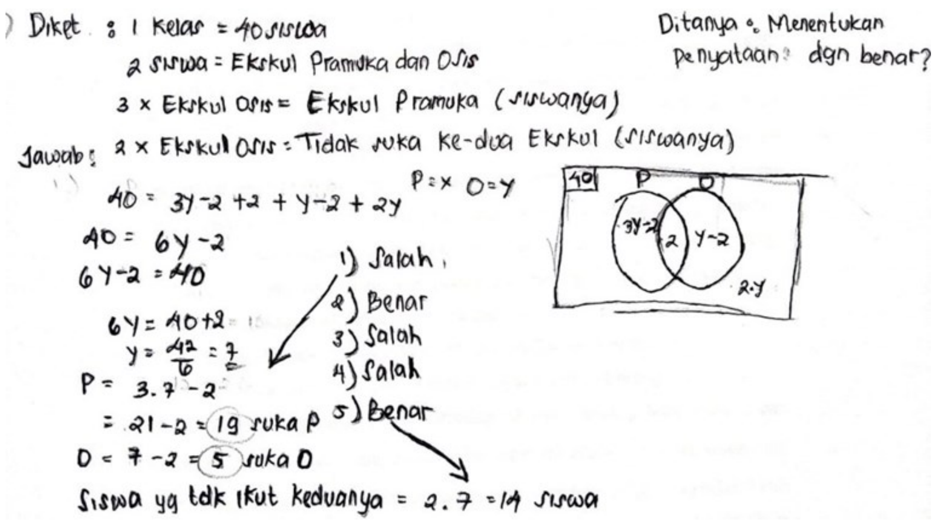


**Fig. 1.** FI Student Problem Solving Results

### E. Problem Solving Analysis in FD Students

In FD students in solving HOTS story questions, there are several stages of Polya solving methods in Table 1 that have not been met. Here is an explanation of solving Polya problems for FD students. At the stage of understanding the problem, at this stage, FD students can understand the given situation well. FD students write down what is known and ask correctly. At the time of the interview, the student also said he could understand what was asked of the question. At the stage of planning solutions, FD students have difficulty preparing a given HOTS problem-solving model. FD students have problems with creating problem-solving models less precisely. The results of FD student interviews reinforce it. Namely, students experience confusion in making a complete model of the questions, even though students understand what is asked from the questions. Furthermore, at getting answers, FD students experience errors in planning solutions, and then FD students reach the final answer incorrectly. The results of the FD student's work can be seen in Figure 2.

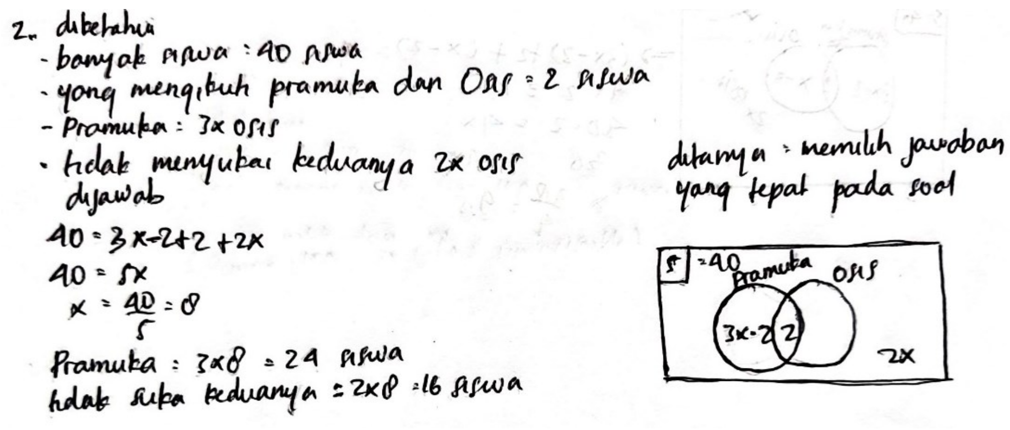


**Fig. 2.** FD Student Problem Solving Results

The results of the analysis of student problem-solving in solving HOTS story problems are seen from the cognitive style as follows. FI students in solving problems can understand the situation well, write it down and be asked correctly. It is under the results of research [28], which said FI students could express in their sentences what is known and requested from the questions. It is also in line with the results of [29] that FI students can understand the problem well, and the subject can write down the known elements of the problem completely and correctly. FI students have also been able to create a completion model that will be used correctly, as well as being able to make even diagrams well. It is also in line with [30] that FI subjects tend to be able to develop problem-solving plans well. In problem-solving, FI students experience errors in drawing the conclusion, which results in FI students getting the definitive answer incorrectly. The error occurs because the student does not double-check the solutions that have been obtained. It is also in line with [30] that FI subjects tend to be less able to re-examine their work.

FD students can understand the problems given well in solving problems about HOTS stories. FD students also write down what is known and asked correctly. It is in line with [29] that field-dependent subjects can understand the problem well. FD students have difficulty making problem-solving models for hots questions; this is evidenced by students being not precise in making problem-solving models and not being accurate in making diagrams. FD students experience confusion in creating a solving model of the problem, even though student understands what is asked. It is in line with [29] that FD students are not complete in strategizing, so students experience errors in problem-solving strategies. It is also in line with the results of Ref. [6], namely that FD students tend not to be able to apply known and requested information in the form of variables or labels (mathematical models). Furthermore, in getting answers, because FD students experienced errors in making mathematical models, FD students reached the final answer incorrectly. It is also following the results of research by

[31] that students who have an FD cognitive style usually find it more challenging to make a solution to a problem independently.

Based on the results of the mathematical problems of FI and FD students that have been put forward, there is no difference between the two at the step of understanding the problem. FI and FD subjects can write down the known and ask correctly. The difference in problem-solving occurs in planning a solution and getting an answer. In planning solutions, FI students are appropriate and correct in making mathematical models. However, they are not careful in concluding. At the same time, FD students still have difficulty making mathematical models, so in getting answers, FD students are also not correct. It is in line with the research of Ref. [28] that there are differences between FI and FD students in implementing mathematical problem-solving plans.

## Conclusion

Based on the problem-solving analysis of HOTS story problems, it can be concluded that FI and FD students understand the problem. There is no difference. FI and FD students are good at understanding the problem. FI students and FD students have differences in the stages of planning solutions. FI students plan solutions well and can correctly create mathematical models, while FD students have difficulty creating mathematical models. In getting answers, FI and FD students have something in common, which is not quite right in the final answer, even though FI students are approaching the correct answer.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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