

Analysis of Problem Solving Ability on Pythagorean Theorem Topics in Terms Cognitive Style

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Abstract

The acquisition of problem-solving skills in students is intended to provide them with the capacity to comprehend issues, devise mathematical models, solve these models, and analyze the resulting answers. The problem-solving capacity of students is influenced by various factors. One aspect that can impact pupils' problem-solving skills is their cognitive style. The aim of this study was to assess the problem-solving skills of eighth-grade students at SMP IT Abu Bakar Yogyakarta in relation to the Pythagorean theorem, as well as their cognitive style. This research will be used qualitative approach. The data collection is conducted with various techniques and instruments, such as GEFT test, problem solving ability test, interview, and analysis techniques. This research involved 31 students of class VIIIIG with six main subjects consisting of 3 students with the same cognitive style. The result of this research indicate that of the 31 students, field dependent cognitive style dominates with the number of 25 students. Students with a field independent cognitive style demonstrate proficiency in all aspects of problem solving ability, including recognizing the problem, devising a plan, executing the plan, and evaluating the outcome. Field dependent cognitive type students demonstrate proficiency in two out of the four indicators of problem-solving abilities, specifically grasping the problem and devising a plan

Keywords: problem solving ability, Pythagorean theorem, Cognitive style, Field Independent, Field Dependent

INTRODUCTION

In order for a country to develop and not be left behind by other countries, one of the most important factors is education. Through education, we can produce the next generation of the nation who are expert in all fields. Education starts at a young age, from early childhood education to higher education. This education will help to serve the society in the future (Rahmawati, 2020). Education is in line with the learning process that students get at every level. The current learning process tends to the cognitive aspect where participatory learning or involving students to play an active role in practical learning activities such as conducting investigations and building knowledge of the surrounding environment. The learning method used is centered learning to encourage students to take an active role in learning activities, including in learning mathematics (Lapase, 2021).

In particular, mathematics consists of unified parts, so that one part is related to another (Fikriyyah, 2020). Mathematics cannot be separated from other disciplines, as well as problems in daily life. Based on this information, it demonstrates the significance of problem-solving abilities in tackling everyday mathematical difficulties. The purpose of problem-solving ability is to provide students with measures of their

capacity to recognize problems, develop mathematical models, solve such models, and analyze the resulting answers. The process of issue solving is intricate as it necessitates students to effectively integrate their experience, knowledge, and comprehension to tackle problems and successfully demonstrate all aspects of problem solving proficiency (Lambertus et al., 2020).

As stated by Bernard et al. (2018), students should possess problem-solving skills that enable them to effectively address challenges in their academic pursuits, such as mathematics, physics, chemistry, and the ever evolving field of technology and information. Problem solving is a learning approach that enhances and develops problem-solving skills during educational tasks. Problems that can be used in learning activities can come from everyday phenomena or problems that occur in the environment around students.

Currently, problem solving skills in Indonesia are relatively poor. An example that arises is when students encounter mathematical problems that necessitate analysis. Students are sometimes unaccustomed to explicitly stating the given information and the problem's requirements, leading to occasional misinterpretation of the problem's meaning (Sinaga et al., 2022). In addition, it can also be seen from the test results conducted by two international studies, namely the Programme for International Student Assessment (PISA). According to the 2018 PISA report, Indonesian students ranked 72nd out of 78 nations in terms of their math scores, achieving an average score of 379. According to the PISA findings, students in Indonesia are only able to achieve level 2. This indicates that the number of students who can comprehend information from PISA questions and solve them using the correct ideas is still quite low (McComas, 2018). This can show that problem solving skills in Indonesia still tend to be poor.

According to the interviews conducted with Maria Noor Cahaya Budhi, M.Pd, who is the 8th grade mathematics teacher at SMP IT Abu Bakar Yogyakarta, it was found that students have a weak understanding of the information presented in the problem. As a result, they struggle to devise a solution plan for the given problem. Therefore, students also find it difficult to solve problems because they are constrained when completing the plans that have been made. In addition, students also do not check again on their own work. Maria Noor Cahaya Budhi, M.Pd said that students tend to solve problems directly in the form of numbers more easily than problems in the form of stories from everyday life. One of the materials that use problem solving skills in class VIII is the Pythagorean theorem topic.

Pythagoras is used to determine the type of right triangle if the side lengths are known. One of the subjects in pythagoras is the comparison of side lengths in a triangle. This subject matter is used to solve problems related to right triangles. Many students are often having difficulty in solving problems related to the comparison of the side lengths of these triangles. Sometimes students still cannot understand the problems given properly, as a result students have errors in related calculations, and students do not re-check the completion of the given problem. Consistent with those, according to Polya (1973) there are four indications of issue solving: recognizing the problem, devising a plan, executing the plan, and re-evaluating the solution. Thus, if students have not met the four criteria for problem-solving ability as defined by Polya, it can be concluded that the problem-solving ability of students is still inadequate. One effective approach to improve students problem-solving skills is to identify and understand their cognitive style. According to Restianingsih & Pujiastuti (2020), individuals have varying methods and cognitive styles when it comes to problem-solving. Cognitive styles are cognitive types that can be used to express individual distinctions.

The students cognitive style can affect problem solving ability because each student has different cognitive factors. Cognitive style, as defined by Hanifah (2019), refers to the unique approach that a student takes in learning. This encompasses their methods of acquiring and processing knowledge, their attitudes towards information, and their habits in relation to the learning environment. Cognitive and learning styles can serve as reliable indicators for determining the most suitable teaching strategies or methodologies for individuals and certain learning tasks. The findings of Ulya's (2015) study indicate a strong positive link between cognitive style and mathematical problem-solving ability. This suggests that students with greater levels of cognitive style tend to have stronger mathematical problem-solving abilities. Hence, it is believed that cognitive style has an impact on mathematical aptitude when it comes to solving mathematical issues (Yunus et al., 2020).

Romani (2020) classifies cognitive types as either Field Independent (FI) or Field Dependent (FD). According to Arifin (2015), students with a FI cognitive style have a preference for independent learning, are self-reliant, and do not rely on others. On the other hand, students with an FD cognitive style prefer learning in groups, frequently engage with others, and seek external reinforcement. According to Santia's (2015) research findings, students with a field dependent cognitive style tend to heavily rely on pictures when solving problems. Conversely, students with a field independent cognitive style do not always use pictures, but instead have a wide range of symbol representations that are highly effective. Additionally, a study conducted by Khakim (2016) found that students with an FD cognitive style exhibit a propensity for good problem-solving skills. Students that possess the FI cognitive style generally exhibit a lesser level of problem-solving proficiency compared to students with the FD cognitive type. The above description illustrates the correlation between various cognitive styles and the problem-solving proficiency of students. It suggests that students with distinct cognitive styles exhibit varying levels of problem-solving capabilities (Restianingsih & Pujiastuti, 2020).

The research will investigate the problem-solving capacity in Pythagorean Theorem material, focusing on the cognitive style of field dependent and field independent students. The research attempts to characterize the problem-solving proficiency of students when addressing Pythagorean theorem problems, specifically in relation to their cognitive style, either field dependent or field independent.

METHODS

A qualitative approach is the approach that will be used in this research. The research data is collected using various techniques and instruments, such as GEFT test, problem solving ability test, interview, and analysis techniques. This research will be conducted at SMP IT Abu Bakar Yogyakarta. This study uses a qualitative descriptive approach with the hope that it can reveal more closely the mathematical problem solving ability of students in the Pythagorean Theorem topics in class VIII, especially VIII G in terms of the cognitive style of students. The main subjects of this study were 6 students who were selected using purpose sampling. Purpose sampling is a sampling technique based on certain considerations (Sugiyono, 2016). The selection of research subjects was made by utilizing cognitive style test tools that have gone through substantial validity testing. Additionally, input from teachers who possess a deeper understanding of each student's qualities was taken into consideration. Prior to identifying the primary focus, researchers administered a problem-solving assessment pertaining to the Pythagorean Theorem to 31 students in class VIII G.

RESULTS AND DISCUSSION

The GEFT test findings revealed that the majority of students in Class VIII G SMP IT Abu Bakar Yogyakarta exhibited a field dependent cognitive style, with a total of 25 students. Conversely, only 6 students demonstrated a field independent cognitive style. Cognitive style test results can be seen from the following table 1.

Table 1. GEFT Test Result

Cognitive Style	Number of Students
<i>Field Independent</i>	6
<i>Field Dependent</i>	25

According to the GEFT test results in table 1, it is seen that there are 6 students with the FI cognitive style and 25 students with the FD cognitive style. Moreover, three respondents will be selected from each cognitive style to complete a test consisting of questions linked to the Pythagorean theorem. The subjects included in this investigation are displayed in table 2.

Table 2. Code for Research Subjects

No	Code	Cognitive Style
1	FD1	<i>Field Dependent</i>
2	FD2	<i>Field Dependent</i>
3	FD3	<i>Field Dependent</i>
4	FI1	<i>Field Independent</i>
5	FI2	<i>Field Independent</i>
6	FI3	<i>Field Independent</i>

Table 2 illustrates 6 subjects, specifically students with the codes FD1, FD2, and FD3 for field dependent cognitive style, and students with the codes FI1, FI2, and FI3 for field independent cognitive style. According to the outcomes of the GEFT exam, there were three students classified as having low, medium, and high levels. GEFT test scores in the range of 0-9 will be taken as field dependent subjects and 3 students with low, medium and high GEFT test scores in the range of 10-18 will be taken as field independent subjects. Furthermore, selecting subjects also goes through consideration from teachers who know more about the characteristics of students.

Following the selection of six subjects, the researchers proceeded to analyze the problem-solving proficiency of students in relation to issues on the Pythagorean Theorem, the descriptions of problem solving ability in terms of cognitive style are as follows.

1. Problem Solving ability of Field Dependent Cognitive

There are 3 students namely FD1, FD2 and FD3 who will be given a problem test on the pythagorean theorem. Based on the responses to problem number 1, it is evident that FD 1 and FD 2 are capable of executing multiple indicators in problem solving, specifically Recognizing the Problem, Devising a Plan, and Executing the Plan. For FD 3, they are capable of performing the indications for recognizing the problem, devising a plan, and evaluating the outcome. Furthermore, for problem number 2, FD 1 and FD 2 both could not fulfil all indicators of problem solving, while FD 3 could only recognize the problem. For the last problem, which is number 3, FD 1 and FD 3 can only fulfil the indicators of Recognizing the problem and devising a plan while FD 2 can fulfil the

3 steps of problem solving with the same phase in number 1. Aside from the problem solving test on the pythagorean theorem, the researcher also conducted in-depth interviews with FD1, FD2 and FD3. Here is a triangulation table of subjects FD1, FD2, and FD3 with field independent cognitive style.

Table 3. Triangulation of Field Dependent Cognitive Style

Indicator	Subjek			Conclusion
	FD1	FD2	FD3	
Recognizing the Problem	✓	✓	✓	✓
Developing a Plan	✓	✓	✓	✓
Executing the Plan	x	✓	x	x
Evaluating the outcome	x	✓	x	x

Based on the information presented in Table 3, it can be inferred that students with a field dependent cognitive style are only able to meet two out of the four indications of problem solving abilities. These two indicators involve recognizing the problem and devising a plan. According to Ahna et al.'s (2022) research, individuals with a field dependent cognitive style have a reduced ability to analyze moderately challenging problems and rely on instructions from researchers to solve them.

Based on the results of tests and interviews, three field dependent subjects, namely FD1, FD2, and FD3, can carry out the stage of understanding the problem. However, subjects FD1 and FD2 could not carry out this stage in problem number 2 because they made mistakes in identifying the information in the problem, so it did not match the context of the problem. In addition, all subjects can receive information from other problems properly and accurately. Meanwhile, at the stage of making plans, all field dependent subjects cannot carry out in problem number 2, because FD1 and FD2 subjects have made mistakes when understanding the problem, while FD3 subjects cannot make plans because the formula used is wrong. However, for questions number 1 and 3 all field dependent subjects can carry out the planning stage. For the stages of carrying out the plan and checking back can only be fulfilled by subject FD2 because in questions number 1 and 3 subject FD2 can find the final result of the problem in the problem correctly and check the answer again.

This is the description of the problem solving ability of one student who has a field dependent cognitive style on question number 3 (Doni will rig a flagpole propped up by three equally long ropes around it. Each rope will be tied 2.4 m high to the flagpole and tied to 3 pegs 0.7 m away from the flagpole. If Doni already has 4 m of rope, how much more rope must Doni buy to support the flagpole so that it can stand firm)?

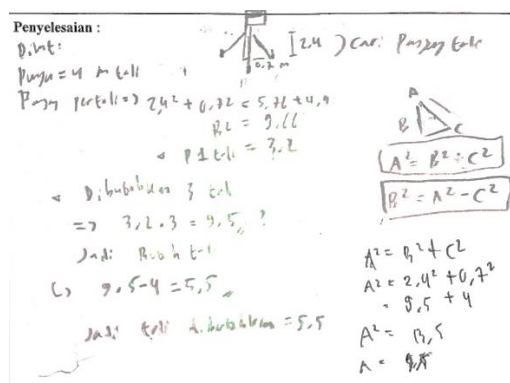


Figure 1. Answer FD 1 Students

Figure 1 illustrates the answer written by subject FD1, it can be seen that subject FD1 can recognize the problem correctly and write it down and draw illustrations of the problem well. Subject FD1 can also determine the steps or formulas used to solve problem number 3. However, it can be seen that the calculations made by subject FD3 are still not correct. So that subject FD1 has not been able to draw the right conclusion according to the context of the problem. Researchers conducted interviews to gather more comprehensive data. Here are the results of the interview conversation between the researcher and FD 1.

P: Okay, let's move on to number 3, can you read question number 3 first?
FD1: (reading question number 3)
P: From the question, what is known and asked?
FD1: It is known that the rope owned by Doni is 4m, then the height of the rope tied to the pole is 2.4m, the distance between the peg and the pole is 0.7m, and there are 3 pegs. Then what is asked is how much more rope Doni needs to buy.
P: Then what steps did you use to solve the problem?
FD1: I found the length of the rope
P: What formula did you use to find the length of the rope?
FD1: I used the Pythagorean formula by finding the hypotenuse.
P: Okay, then tell me about the Pythagorean calculation.
FD1: The equation is still like before, B is the hypotenuse so $B^2=A^2+C^2$ then the numbers are inputted $[2,4]^2 + [0,7]^2$ the result is 5,67+4,9 the result is 9,66 then rooted I found the result 3,2 then the result is multiplied by 3 so I found 9,5,9,5 minus 4 because I already have a 4m rope the rest is 5,5m.
P: Try checking the squared result again.
FD1: I found 5.67 and 4.9.
P: That should be 0.7, the result is 0.49 not 4.9, so the sum result is also wrong.
FD1: Oh yes, I miscalculated kak
P: Okay, if you use your calculation, what is the conclusion?
FD1: The lack of rope needed by Doni is 5.5m.
P: Did you check this answer again earlier?
FD1: I didn't check it again either
P: Then you are sure of the answer
FD1: Yes, sure

Figure 2. Interview result with FD 1 related to problem number 3

Based on the interview results in Figure 2, it is known that the subject made a mistake in the square operation of decimal numbers. So that the next stage of completion is also wrong. In addition, the subject also did not checking his answer again because he was sure of the final result. Therefore, subject FD1 could not fulfil the third and fourth problem solving indicators.

2. Problem Solving Ability of Field Dependent Cognitive

For students that possess a field independent cognitive style, denoted as FI 1, FI 2, and FI 3. The three students were also assigned challenges pertaining to the Pythagorean theorem. Regarding problem number 1, students FI 1, FI 2, and FI 3 demonstrate proficiency in all four problem-solving indicators, namely recognizing the problem, devising a plan, executing the plan, and evaluating the outcome. Regarding problem number 2, both FI 1 and FI 2 students successfully meet all four indicators of problem solving, whereas FI 3 students fail to meet any of the signs of problem solving. Regarding the final problem, both FI 1 and FI 3 students are capable of meeting three problem-solving indications: recognizing the problem, devising a plan, and executing the plan. On the other hand, FI 2 students are able to fulfill all problem-solving indicators. Table 4 illustrates the triangulation of the three individuals based on an analysis of the exams and in-depth interviews.

Table 4 Triangulation of Field Independent Cognitive Style

Indicator	Subjek			Conclusion
	FI1	FI2	FI3	
Recognizing the Problem	✓	✓	✓	✓
Developing a Plan	✓	✓	✓	✓
Executing the Plan	✓	✓	✓	✓
Evaluating the outcome	✓	✓	x	✓

Based on the data in table 4, it is evident that students with a field independent cognitive style demonstrate proficiency in all four stages of problem-solving skill indicators, namely recognizing the problem, formulating a plan, executing the plan, and evaluating the outcomes. Therefore, it aligns with the findings of Yunus et al. (2020) that individuals with a field independent cognitive style possess an analytical thinking approach and are self-reliant, not relying on assistance from others.

According to the test and interview results, all subjects who are field independent, specifically FI1, FI2, and FI3, are capable of demonstrating recognizing of the problem, Devising a plan, and executing the plan. Nevertheless, subject FI3 failed to meet all the indicators for problem-solving skills in problem number 2 due to errors made during the stage of problem recognize. Subject FI3 could not meet all the indicators of problem-solving abilities when addressing problem number 2.

For the final stage of the test, the three field independent subjects were able to draw conclusions on all answers to the test. For the indicator of rechecking the results of FI2's work on all three tests and FI1 did not check the answer to question number 3. Meanwhile, FI3 subjects did not check back on questions number 1 and 2 to solve the problem.

The following is a description of the problem solving ability of one of the students who have a field independent cognitive style on problem number 2 (Andra's uncle has a rectangular garden whose diagonal length is 13 m and the width of the garden is 5 m. Andra's uncle will put the lamps around the garden. He's going to install lamps around the garden with a distance of 2 m between each lamp. If Andra's uncle has bought 15 lamps, what is the remainder or shortage of lamps that Andra's uncle has?)

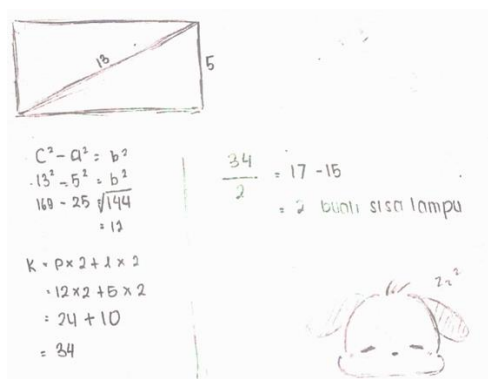


Figure 3. Answer of FI 2 Students

From Figure 3, it can be seen that the written answer by the FI2 subject shows that the FI2 subject can understand the information and questions in the problem correctly. It can be seen that the FI2 subject wrote down the information contained in the problem by describing the illustration in accordance with the problem. Furthermore, FI2 subject can develop a plan to solve the problem using the pythagorean theorem and perform calculations correctly and precisely. At the end of

the work it can be seen that the FI2 subject can find the final result and conclusion of the work. Interviews were also conducted by researchers to obtain more in-depth data. Here are the results of the interview conversation between the researcher and FI 2

P: Moving on to question number 2, can you read the question first?
FI2: (reading question number 2)
P: What is asked and known from this question?
FI2: The length of the diagonal is 13m and the width is 5m, the distance between each lamp is 2m and then Andra's uncle has 15 lamps.
P: Isn't it written here what is known and asked?
FI2: Not really, sis
P: What is the next step that you do?
FI2: First I drew the sketch, because this is the known diagonal so I made another triangle and used the Pythagorean formula again but here only C and A are known so I just changed them, this is 13m from the diagonal length and 5m from the width. Then the two are squared, well 13^2 is 169 then subtract 25 from 5^2 so the result is 144 then rooted to find 12m. Then that is the result of the length and then we find the perimeter using the formula for the perimeter of a rectangle which is $2p + 2l$ so the calculation is $(12 \times 2) + (5 \times 2)$ so the result is $24 + 10 = 34$ well 34 is divided by 2
P: Why is it divided by 2?
FI2: Because the distance between the lights is 2m, so 34 is divided by 2, which is 17 and then subtract 15, which results in 2 more lights needed by Andra's uncle.
P: Then what is the conclusion?
FI2: So Andra's uncle lacks 2 lamps
P: Did you check your answer again?
FI2: Yes, I checked the calculation again

Figure 4. Interview result with FI 2 related to problem number 2

As in the results of the interview seen in Figure 4, the results of the answers from the interview above strengthen the results of the answers written by the FI2 subject that he can understand the problem well, explain the formulas and calculations performed, so that he can draw conclusions and double-check his answers in question number 2.

CONCLUSION

Out of the 31 students investigated 25 of them exhibited a field dependent cognitive style, whereas only 6 individuals had a field independent cognitive style. According to the findings from tests and interviews, individuals who are field independent are able to successfully meet all the criteria for problem solving, which include comprehending the problem, creating a strategy, executing the strategy, and reviewing the results. Students with a field dependent cognitive style can only meet two out of the four indicators of problem-solving abilities. Specifically, they can grasp the problem and come up with a strategy, but they are unable to execute the plan or evaluate their progress.

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