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Students' Mathematical Problem-Solving Ability Based on Cognitive Style in Flipped Classroom Learning Model Assisted by Sevima Edlink

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Abstract

This research aims were to (1) test the effectiveness of the Flipped Classroom learning model assisted by the Sevima Edlink on students' mathematical problem-solving abilities, and (2) describe students' mathematical problem-solving abilities based on cognitive style in the Flipped Classroom learning model assisted by the Sevima Edlink. This research was a mixed methods type of sequential explanatory design. Quantitative methods were used to test the effectiveness of using the Flipped Classroom learning model on students' mathematical problem-solving abilities while qualitative methods were used to describe students' mathematical problem-solving abilities based on cognitive style in the Flipped Classroom learning model assisted by the Sevima Edlink. Data collection was carried out using problem-solving ability tests, GEFT tests (cognitive style tests), and interviews. The population of this study were all class VIII students of SMP N 1 Pecangaan for the 2022/2023 school year. The samples used were students of class VIII E as the experimental group and class VIII G as the control group. The results of the research conducted showed that (1) the Flipped Classroom learning model was effective in increasing students' mathematical problem-solving abilities, (2) students' mathematical problem-solving abilities in terms of cognitive style were divided into two categories, namely FI (7) and FD (15). The FI category is divided into 3 patterns of problem-solving abilities while students with the FD category are divided into 5 patterns.

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1. Introduction

According to the National Council of Teaching Mathematics (NCTM) cited in Mauleto (2019: 127) mathematical abilities in learning mathematics include 5 (five) main competency standards, namely problem solving, reasoning and evidence (reasoning and proof), communication (communication), connection (connection), and representation (representation). One of the abilities that must be possessed by students is the ability to solve mathematical problems. Referring to the regulation of Minister Education and Culture Number 22 of 2016, it is said that the implementation of learning is recommended to encourage students to produce work based on problem solving. Ardiansyah et al., (2018) explained that learning mathematics needs to be designed in such a way as to encourage students to have mathematical skills, one of which is problem solving.

Problem solving is an activity connecting various concepts and rules that have been obtained previously to solve relevant problems (Harahap & Surya, 2017; Youngchim et al., 2015). Polya (1988) defines problem solving as an attempt to find a way out of a problem in order to achieve a goal. Kirisci et al., (2020) says that the essence of mathematical creativity is problem solving. NCTM (National Council of Teaching Mathematics) says that problem-solving skills in learning mathematics are the main thing, while on the

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other hand it is said that the purpose of learning mathematics is to enable students to solve everyday problems (Phonapichat et al., 2013; Sumartini, 2016) . Barham stated that problem solving is the heart of educational mathematics, therefore the ability to solve problems is an ability that must be possessed by every student (Davita & Pujiastuti, 2020). In this study, the mathematical problem-solving ability (PSA) in question is the ability of students to use mathematical concepts to solve mathematical problems using systematic steps so as to obtain solutions to these problems. This study is guided by indicators of problem-solving abilities quoted from NCTM, namely (1) building new mathematical knowledge through problem solving, (2) solving problems that arise in mathematics and other contexts, (3) applying and adapting various appropriate strategies to solve problems.

But the reality that occurred in the field is not as expected. Based on the results of the 2018 PISA (Program for International Student Assessment) in the mathematics proficiency level section, 40.6% of Indonesian students are only able to work on math problems below level 1, where this level is the lowest level and only 0.4% of students successfully complete problems at level 5 (OECD, 2019). This shows the low level of students' mathematical problem solving ability in Indonesia.The low ability to solve mathematical problems is also a problem at SMP Negeri 1 Pecangaan. Based on the results of interviews conducted with the mathematics teacher at SMP N 1 Pecangaan, it is known that students' mathematical problem-solving abilities are low. Students still have difficulty solving math problems, especially for non-routine problems. This is also evidenced by the results of students' mid-term exams in Mathematic which still have not reached the minimum mastery limit. Only 4 out of 32 students completed the minimum mastery limit.

The use of teaching models and methods where the teacher is the main resource makes students passive and contributes to the lack of students' ability to solve problems. therefore there is a need for innovation in the implementation of mathematics learning, one of which is through the use of the Flipped Classroom learning model assisted by the Sevima Edlink application. Flipped Classroom or reverse class is a learning model where assignments and material in class are reversed, students do homework / assignments at school and learn material at home through providing learning videos, material files, and for discussions carried out at school (Asad et al., 2022) . The focus on learning with this model is more efficient use of time in class, and students taking an active role in learning (Susanti & Hamama, 2019). This model is carried out with two stages of learning, namely the pre-learning stage or before class begins and the active learning stage or the learning stage in class with discussion and deepening of the material (Bergmann & Sams, 2012).

Each student has different characteristics in receiving and processing information which makes a difference in how to solve problems. This difference is caused by the dissimilarity of cognitive styles in students. Cognitive style is a bridge between intelligence and personality which refers to individual characteristics in receiving, storing, and thinking, and using information to solve problems and make decisions that reflect their habits in processing information (Marlissa & Widjajanti, 2015). Each individual must have a different way of solving problems so that the cognitive style they have is also different (Firdausi et al., 2018).Witkin cited in Rastegar & Honarmand (2016), divides cognitive styles into Field Independent (FI) and Field Dependent (FD) cognitive styles where individuals with this FI cognitive style tend to think analytically, independently, and are able to see small parts of the overall pattern while individuals with the FD cognitive style tend to think globally, are less independent, and see patterns as a unified whole (Ulya, 2015; Prabawa, 2017; Sutama et al., 2021; Pradiarti & Subanji, 2022).

The purpose of this study was to determine the effectiveness of the implementation of the Flipped Classroom learning model assisted by the Sevima Edlink application on students' mathematical problem solving abilities and to describe students' mathematical problem solving abilities in terms of cognitive style in the Flipped Classroom learning model assisted by the Sevima Edlink application. Effective learning is learning that can achieve learning objectives (Lutfiyah & Sulisawati, 2019). Referring to Ariyani et al., (2020), in this study the use of the Flipped Classroom learning model is said to be effective if: (1) The ability to solve problems with the Flipped Classroom model achieves classical mastery, that is at least 70% of students reach minimum mastery limit, (2) The average test results for students' problem solving abilities in the Flipped Classroom model assisted by Sevima Edlink are more than students in the conventional learning model (Problem Based Learning), (3) The proportion of the completeness of students' mathematical problem solving abilities in learning with the Flipped Classroom model assisted by Sevima Edlink is more than the ability to solve mathematical problems in conventional learning (Problem Based

Learning), (4) There is a difference in the average results of students' mathematical problem solving abilities before and after the application of the Flipped Classroom learning model.

2. Methods

This study used analysis with a combination method or Mixed Methods of the Sequential Explanatory type. The results of the analysis of problem-solving abilities as a quantitative analysis dominate and were used as the basis for data information which will later be analyzed based on their cognitive style as a qualitative analysis. The cognitive styles analyzed in this study were Field Independent (FI) and Filed Dependent (FD) cognitive styles.

The population in this study were all class VIII students of SMP Negeri 1 Pecangaan for the 2022/2023 academic year. Through a random sampling system, namely Cluster Random Sampling, class VIII E was selected as the experimental class and class VIII G as the control class. The samples used in the analysis of this study were experimental and control class students without including students who had passed the initial ability test or pretest. The control class was taught using the PBL model commonly used by teachers while the experimental class was taught using the Flipped Classroom learning model assisted by the Sevima Edlink application. The initial ability test (pretest) and problem-solving ability test (posttest) were carried out in the experimental and control classes while the GEFT test to determine students' cognitive styles was carried out only in the experimental class. From each of these cognitive style categories, an analysis was then carried out on the results of the problem-solving ability test to obtain patterns of students' problem-solving abilities in terms of cognitive style. One student representative from each pattern was interviewed to obtain supporting data regarding the description of students' mathematical problem-solving abilities in terms of cognitive style.

Data collection methods in this study included pretest and posttest problem solving skills (PSA), GEFT tests (cognitive style tests), and interviews. The type of test used in this study is the problem-solving ability test (PSA) which is carried out at the beginning and at the end of learning. Data analysis was carried out before and after the study. Data analysis before the research was carried out to test the instrument which included validity, reliability, discriminating power, and the level of difficulty of PSA test items. The analysis after the research is a quantitative data analysis of the PSA test which is carried out to answer the research hypotheses which include the classical mean and proportion completeness test, the independent average 2 difference test, the 2-proportion difference test, and the average dependent comparative test.

3. Results & Discussions

The research activity took place on April 3 – April 15 2023. Before carrying out the research, the researcher first prepared the necessary instruments in the form of lesson plans, syllabus fragments, worksheets, grids and problem solving ability questions, GEFT tests, and interview guidelines. After compiling the instrument, the researcher conducted a test of problem-solving abilities in class IX A on March 18, 2023 and analyzed the item items to determine validity, reliability, discriminating power, and level of difficulty of the items so that they could be used as test instruments for problem-solving abilities in experimental class and control class. During the implementation of the research, the problem solving ability test was carried out twice, namely at the beginning before giving treatment (pre-test) and at the end after giving treatment (post-test) to find out whether there is an increase in students' mathematical problem solving abilities in the experimental class. In addition to testing problem-solving abilities, the researcher also conducted the GEFT test in the experimental class to see the cognitive style possessed by each student to be used as material for selecting research subjects.

3.1 The Effectiveness of the Flipped Classroom Learning Model on Students' Mathematical Problem-Solving Ability

From the research, gotten the result that was shown in Table 1. until Table 9. Table 2. Table 1. describes the results of the analysis of the PSA test items, Table 2. describes the results of the PSA test for experimental and control class students.

Table 1. Analysis of the items on the problem solving ability test

Question Number	validity	Reliability	Difficulty Level	Discriminating Power	Information
1.	Valid		Currently	Very well	Used
2.	Valid	Reliable (Very	Currently	Good	Used
3.	Valid	high)	Currently	Good	Used
4.	Valid		Currently	Very well	Used
5.	Valid		Currently	Enough	Used
6.	Valid		Currently	Good	Used
7.	Valid		Currently	Very well	Used
8.	Valid		Currently	Very well	Used

Table 2. Test results of students' mathematical problem solving abilities

Class	Number of pretest students	Number of Posttest Students	Pretest average	Posttest average
*Flipped Classroom*with Sevima Edlink	32	22	60.84	78.5
Conventional (PBL)	32	29	60.48	74.9

Table 3. Normality test

	Class	Sig	Test Criteria	Result
Pretest	Experiment	0.070		H_o accepted
	control	0.054	Accept H_o if Sig mark >	(Data Normal)
Posttest	Experiment	0.081	0.05	
	control	0.153		

Table 4. Homogenity Test

	Sig	Test Criteria	Result
Pretest	0.914	Accept H_o if Sig mark	H_o accepted
Posttest	0.113	> 0.05	(Data Homogen)

Table 5. Completeness of Proportion

z_{count}	$z_{(0.5-\alpha)}$	Sig	Test Criteria	Result
1.717	1.645	0.000	Reject H_o if $z_{count} \geq z_{(0.5-\alpha)}$ or Sig mark < 0.05 (SPSS)	H_o rejected and $H_1 accepted.$

Table 6. Completeness of Mean

t_{count}	$t_{(1-\alpha)}$	Sig	Test Criteria	Result
3.946	1.720	0.000	Reject H_o if $t_{count} \geq t_{(1-\alpha)}$ or Sig mark < 0.05 (SPSS)	H_o rejected dan H_1accepted

Table 7. Comparative test of 2 mean (Independent sample t test)

t_{count}	$t_{(1-\alpha)(dk)}$	Sig	Test Criteria	Result
2.67	1.67	0.008	Reject H_o if $t_{count} \geq t_{(1-\alpha)}$ or Sig mark < 0.05 (SPSS)	H_o rejected dan H_1accepted

Table 8. Comparative test of 2 Proportion

Z_{count}	$z_{(\frac{1}{2}-\alpha)}$	Test Criteria	Result
2.153	1.645	Reject H_o if $z_{count} \geq z_{(\frac{1}{2}-\alpha)}$ or	H_o rejected dan H_1accepted

Table 9. Comparative test of 2 mean (dependent sample t test)

t_{count}	$-t_{\frac{1}{2}\alpha}$	Sig	Test Criteria	Result
-8.196	-2.079	0.000	Reject H_o if $t\ count < -t_{\frac{1}{2}\alpha}$ atau Sig mark < 0.05 (SPSS)	H_o rejected dan H_1accepted

Based on the results of the normality test with SPSS, a significance value was obtained for the experimental class pretest of 0.070 and 0.054 for the control class while in the posttest test a significance value was obtained for the experimental class of 0.081 and 0.153 for the control class.Based on the test criteria then H_o accepted because the significance value is > 0.05.This shows that the test data on the mathematical problem solving abilities of students in class VIII E and VIII G of SMP N 1 Pecangaan come from a population that is normally distributed. As for the homogeneity test, obtainedthe significance value for the pretest data was 0.914 and the posttest data was 0.113. So H_o accepted because the significance value is > 0.05.This shows that both data come from homogeneous populations.

In the proportion completeness test, obtained z_{count} = 1.717 while z_{table} =1.645. For output on SPSS, a significance value (sig) is obtained at 0.000 so that according to z_{count} ,$z_{(0,5-\alpha)}$ and test criteria, H_o rejected and accepted H_1. This shows that the proportion of students who scored more than or equal to the minimum mastery limit reached 70%. Meanwhile, in the average completeness test, obtained a value of t_{count} = 3.94 while t_{table} = 1.72. For the output value in SPSS, a significance value (sig) is 0.000 so that according to $t_{count,}$ $t_{(1-\alpha)}$ and test criteria H_o rejected and H_1 accepted. It shows that student scores using the Flipped Classroom learning model assisted by Sevima Edlink achieve average completeness. From the two, it can be concluded that students with the Flipped Classroom learning model assisted by Sevima Edlink complete classical.

In the comparative test of two independent averages, values of t_{count} = 2.67 and t_{table} = 1.67. While the SPSS output obtained a significance value of 0.008, then based on the testing criteria H_0 was rejected and $H_1$was accepted. So it can be concluded that the average test results of students' mathematical problem solving abilities with the Flipped Classroom learning model are more than the average results of students' tests with the conventional model (PBL). While in the comparative test of proportions, values z_{count} were obtained 2.153 and z_{table} = 1.645. So based on the testing criteria H_0 was rejected and$H_1$was accepted, which means that the proportion of students passing the mathematical problem solving ability test using the Flipped Classroom learning model is more than the proportion of students completing conventional classes.

From the results upaired data comparison, obtained that t_{count} = -8.196 and $-t_{\frac{1}{2}\alpha}$= -2.079 while the output in SPSS obtained a significance value = 0.000 where this value is <0.05. Then based on the test criteria H_0 rejected and H_1 accepted. It means that there is a difference in the average or increase in students' mathematical problem solving abilities before and after being given treatment. The average test result after giving treatment (using Flipped Classroom model learning) is higher than the average test result before treatment. This shows an increase in students' ability to solve problems before and after giving treatment. Thus it can be concluded that the implementation of the Flipped Classroom learning model assisted by Sevima Edlink is effective on students' mathematical problem solving abilities.

3.2 Students' Cognitive style Classification

From the GEFT test results, 22 experimental class students obtained 7 students in the Field Independent (FI) cognitive style category and 15 students in the Field Dependent (FD) cognitive style category. Table 10. describes the results of the students' GEFT tests.

Table 10. The results of the experimental class students' cognitive style tests

Cognitive Style	The number of students
Independent Fields(FI)	7 Students
Dependent Fields(FD)	15 Students

After the GEFT test was carried out, an analysis was carried out on the results of the students' final problem solving abilities test (posttest) and the students' GEFT test results to find patterns of students' mathematical problem solving abilities in terms of cognitive style. Students in the FI (Field Independent) category are divided into 3 patterns of problem solving abilities, namely students who achieve all four PSA indicators (Indicators 1, 2, 3, and 4) as many as 2 people, students who achieve three PSA indicators (Indicators 1, 2, and 4) as many as 3 people, and students who achieve two PSA indicators (Indicators 2 and 4) as many as 2 people. The other side, students in the FD (Field Dependent) category are divided into 5 patterns of problem solving abilities, namely students who achieve two PSA indicators (Indicators 1 and 3) as many as 2 people, students who achieve two PSA indicators (Indicators 1 and 2) as many as 5 people, students 2 people who achieved two PSA indicators (Indicators 2 and 4), 4 students who achieved three PSA indicators (Indicators 1, 2, and 3), and students who achieved three PSA indicators (Indicators 1, 2, and 4) 2 persons. After the patterns of problem-solving abilities in terms of students' cognitive styles have been found, then unstructured interviews are conducted on each pattern in order to validate the test results of students' problem-solving abilities.

Table 11. Student PSA research subjects in terms of cognitive style

Cognitive Style	PSA pattern	Research subject
FI	First Pattern	E-05
	Second Pattern	E-26
	Third Pattern	E-01
FD	First Pattern	E-24
	Second Pattern	E-28
	Third Pattern	E-32
	Fourth Pattern	E-09
	Fifth Pattern	E-27

3.3 Description of Problem Solving Ability Based on Cognitive Style in the Sevima Edlink Assisted Flipped Classroom Learning Model

After conducting interviews with the eight subjects, an analysis of students' mathematical problem-solving abilities was obtained in terms of cognitive style in the Flipped Classroom learning model assisted by Sevima Edlink as shown in Table 12.

Table 12. Analysis of students' mathematical problem solving abilities in terms of cognitive style in the Flipped Classroom learning model

Cognitive Style	subject	Problem Solving Ability Indicator			
		Indicator 1	Indicator 2	Indicator 3	Indicator 4
FI	E-05	√	√	√	√
	E-26	√	√	–	√
	E-01	√	√	–	√
FD	E-24	√	–	√	–
	E-28	√	√	–	–
	E-32	–	√	–	–
	E-09	√	√	√	–
	E-27	√	√	–	√

3.3.1 Students' Mathematics Problem Solving Ability with Field Independent Cognitive Style

Based on the results of subject interviews in each pattern, it was found that the subject of the first pattern of cognitive style (E-05) was able to achieve the four indicators of problem solving abilities well. This is in accordance with the analysis of students' work results on tests of mathematical problem solving abilities.

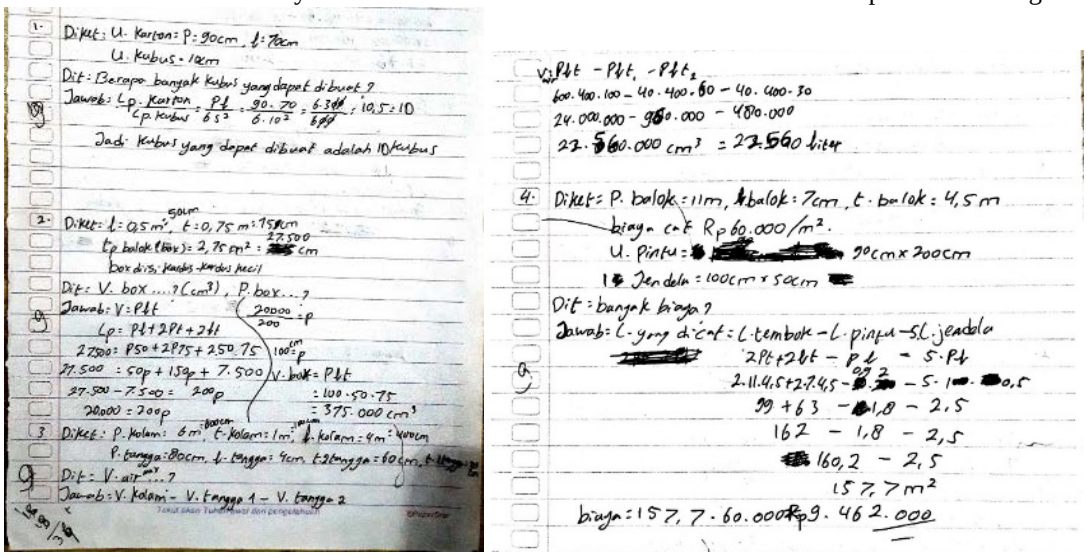


Figure 1. Student worksheet for subject FI pattern 1

The second pattern FI subject (E-26) was able to fulfill all three indicators of problem solving ability, namely indicators 1, 2, and 4. Subjects were less able to use the right strategy in solving math problems and were still wrong in their calculations. This is in accordance with the analysis of students' work results on tests of mathematical problem solving abilities.

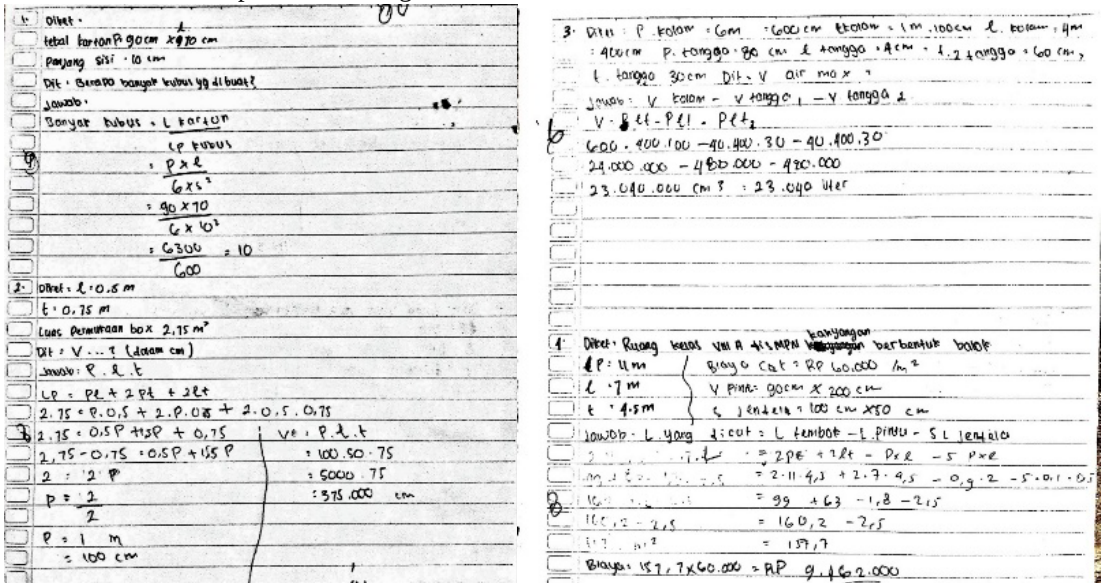


Figure 2. Student worksheet for subject FI pattern 2

The third pattern FI subject (E-01) in his interview was able to achieve three indicators of problem solving abilities, namely indicators 1, 2, and 4 while from the results of his PSA test, the subject is able to achieve 2 indicators, namely indicators 2 and 4. The subject has not been able to perfectly understand the problem properly and use the right strategy.

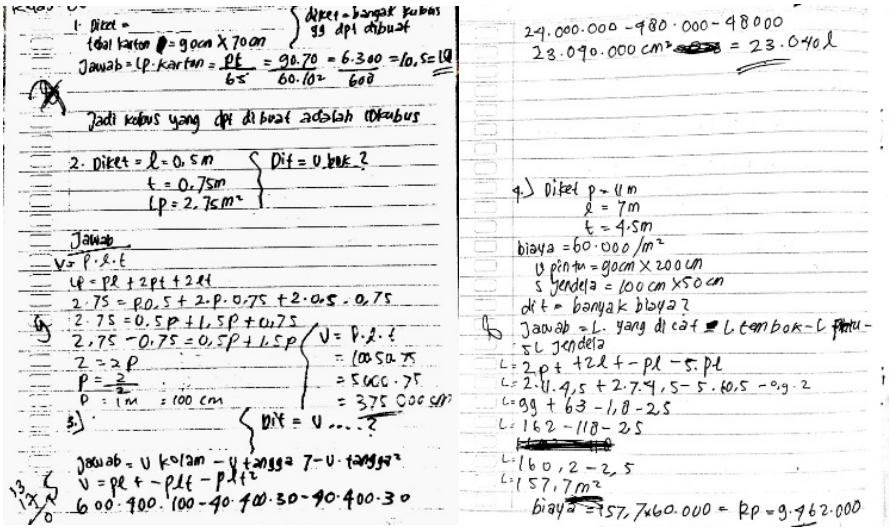


Figure 3. Student worksheet for subject FI pattern 3

Overall, students with the FI (Field Independent) cognitive style were able to achieve 3 indicators of mathematical problem solving abilities. This is in line with research conducted by Prabawa (2017) and Pradiarti & Subanji (2022) that students with the FI cognitive style are able to achieve indicators of problem solving abilities very well. Based on the categorization using categories adapted from Mawaddah & Hana (2015) the results obtained from 7 students in the FI category, 3 students had very good problem solving skills, 2 students had good problem solving skills, and 2 students had fairly good problem solving skills. The subject has not been able to perfectly understand the problem properly and use the right strategy. Overall, students with the FI (Field Independent) cognitive style were able to achieve 3 indicators of mathematical problem solving abilities. This is in line with research conducted by Prabawa (2017) and Pradiarti & Subanji (2022) that students with the FI cognitive style are able to achieve indicators of problem solving abilities very well.

3.3.2 Students' Mathematics Problem Solving Ability with Field Dependent Cognitive Style

The results of interviews with FD subjects found that FD subjects in the first pattern (E-24) were able to achieve 2 indicators of problem-solving ability well, namely indicators 1 and 3. This is in accordance with the analysis of students' work results on tests of mathematical problem-solving abilities. The subject had not been able to solve problems in the context of mathematics or other contexts and had not been able to reflect on the problem-solving process well.

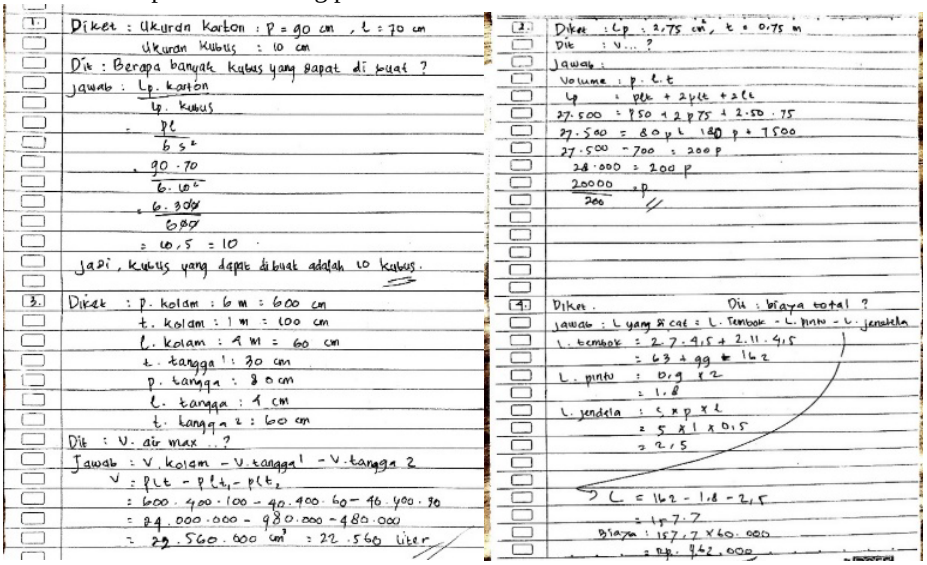


Figure 4. Student worksheet for subject FD pattern 1

Subjects of the second pattern of FD (E-28) were able to fulfill 2 indicators of problem solving abilities, namely indicators 1 and 2. Subjects still had difficulties in using the right strategy and reflecting on the problem solving process well.

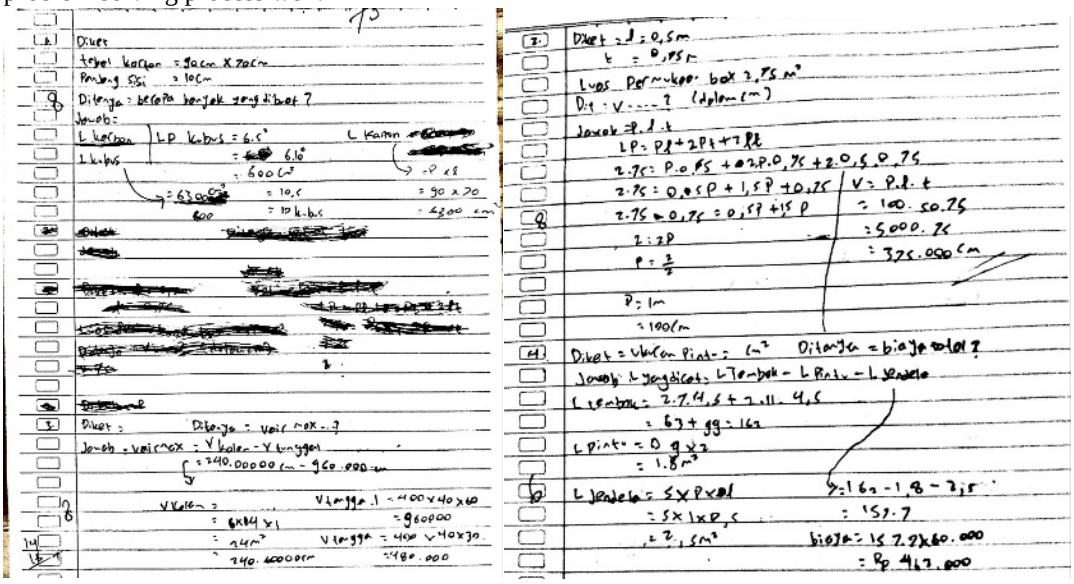
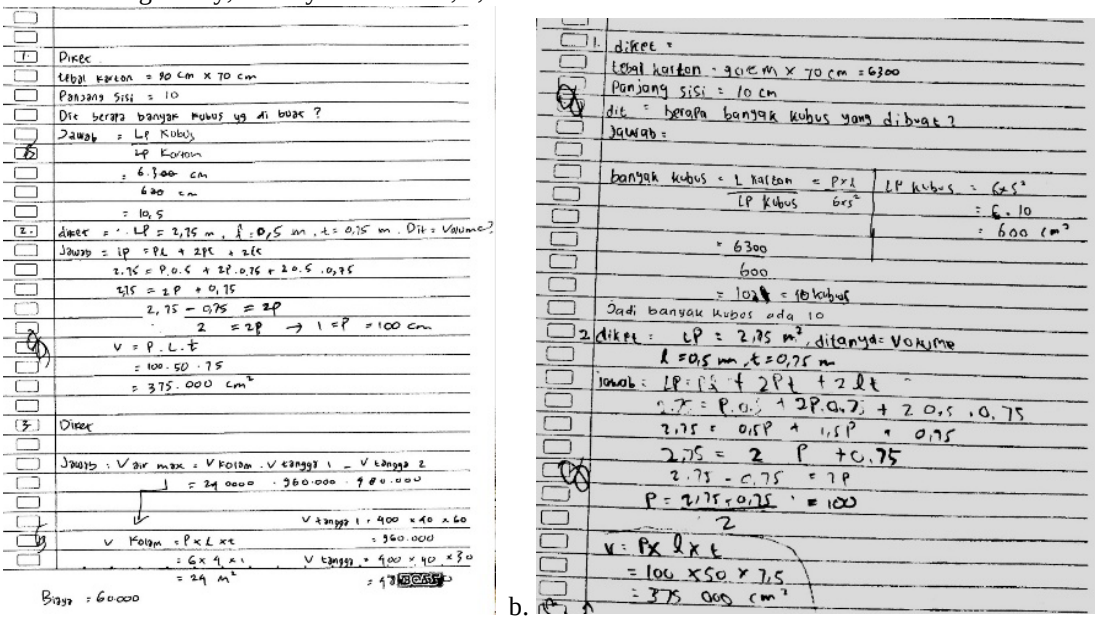


Figure 5. Student worksheet for subject FD pattern 2

The third pattern FD subject (E-32) in his interview was only able to achieve 1 indicator of perfect problem solving ability, namely indicator 4 while from the results of his PSA test, the subject was able to achieve 2 indicators, namely indicators 2 and 4. This shows that the subject has not been able to achieve indicator 2 perfectly. The FD subject in the fourth pattern (E-09) in his interview was able to fulfill three indicators of problem solving ability, namely indicators 1, 2, and 3.



a. b.

Figure 6. Student worksheet for subject FD (a) pattern 3 and (b) pattern 4

The FD subject in the fifth pattern (E-27) in his interview was able to achieve three indicators of problem solving ability, namely the indicator 1, 2, and 4. This is in accordance with the analysis of students' work results on tests of mathematical problem solving abilities. The subject has not been able to use the right strategy in solving math problems.

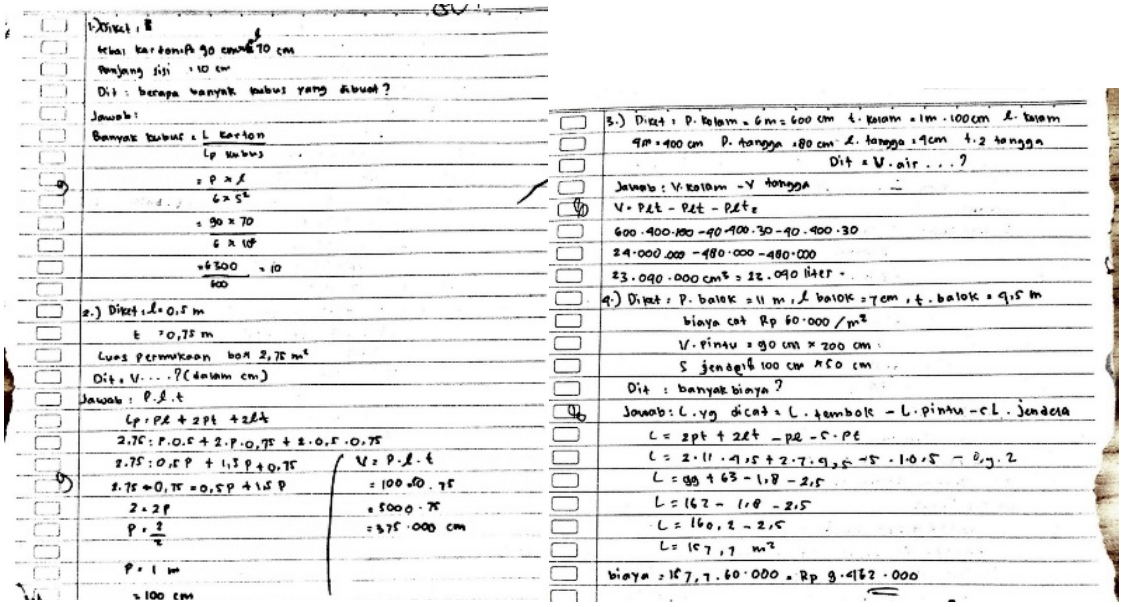


Figure 7. Student worksheet for subject FD pattern 5

Thus, it can be concluded that the average FD subject is able to achieve 2 to 3 problem solving indicators. This is in line with research conducted by Pradiarti & Subanji (2022) that students with the FD cognitive style are able to achieve indicators of problem solving ability quite well. Based on the categorization using categories adapted from Mawaddah & Hana (2015), out of 15 students in the FD category, 1 student had very good problem solving skills, 7 students had good problem solving skills, and 7 students had fairly good problem solving skills.

4. Conclusion

Armed with the results of research that has been carried out by researchers at SMP Negeri 1 Pecangaan related to students' mathematical problem solving abilities in terms of cognitive style in the Flipped Classroom learning model assisted by the Sevima Edlink application with teaching material surface area and volume of cube blocks, it is concluded that the implementation of the model Flipped Classroom learning is effective in increasing students' mathematical problem solving abilities with criteria (1) Students using the Flipped Classroom learning model assisted by Sevima Edlink achieve completeness classically, (2) The average value of students' mathematical problem solving abilities in the Flipped Classroom learning model assisted by Sevima Edlink higher than the average value of students' mathematical problem-solving abilities in the conventional learning model, (3) The proportion of students' mathematical problem-solving ability completeness in the Flipped Classroom learning model is higher than the proportion of students' mathematical problem-solving ability completeness in the conventional learning model, (4) There is an average difference in students' mathematical problem-solving skills before and after applying the Flipped Classroom learning model. The average students' mathematical problem-solving ability after applying the Flipped Classroom learning model is higher than the average student's ability before the model is applied. While in the description of students' cognitive style it is divided into two categories, namely the Field Independent (FI) and Field Dependent (FD) categories. Based on the results of the GEFT test conducted on 22 experimental class students, 7 students were included in the FI cognitive style category and 15 students were included in the FD cognitive style category. The FI category is divided into 3 patterns of mathematical problem-solving ability with 2 students having very good problem-solving abilities, 3 students having good problem-solving abilities, and 3 students having good enough problem-solving abilities. Students in the FD category were divided into 5 patterns with 1 student having very good problem-solving abilities, 7 students having good problem-solving abilities, and 7 students having good enough problem-solving abilities. students with the FI cognitive style have a better mathematics problem solving abilities than students with FD cognitive style.

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