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The Effectiveness of Learning Models on Written Mathematical Communication Skills Viewed from Students' Cognitive Styles

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Abstract: This research aims to test (1) the effectiveness between problem posing learning model with Indonesian realistic mathematical education approach and problem posing learning model on written mathematical communication skills, (2) the effectiveness between field-independent and field-dependent cognitive styles on written mathematical communication skills, (3) the effectiveness between problem posing learning model with Indonesian realistic mathematical education approach and problem posing learning model on the written mathematical communication skills from each cognitive style, and (4) the effectiveness between field-independent and field-dependent cognitive styles on written mathematical communication skills from each learning model. This quantitative research employed a quasi-experimental method. The research sample consisted of 240 fifth-grade elementary school students in Jebres District, Surakarta, Indonesia. Data collection techniques included tests of written mathematical communication skills and cognitive styles. The data were analyzed using prerequisite (normality, homogeneity, and balance), hypothesis, and multiple-comparison tests. The findings prove that (1) PP model with Indonesian realistic mathematical education approach is more effective than the PP and direct instruction models, (2) field-independent cognitive style is better than field dependent, (3) PP with Indonesian realistic mathematical education is as effective as the PP model, but more effective than the direct instruction model, and the PP model is more effective than the direct instruction model in each cognitive style, and (4) in the PP learning model with Indonesian realistic mathematical education approach, field-independent cognitive style is same skill as with field-dependent, but field-independent is better than field-dependent cognitive style in the PP and direct instruction learning models.

Keywords: *Written mathematical communication skill, cognitive style, problem posing, Indonesian realistic mathematics education approach.*

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Introduction

Technology develops rapidly in the 21st century. The development in this century is often called the revolution of industry. Then, various countries called it the 5.0 era. In this case, everyone is required to think more critically, creatively, and responsively in keeping pace with technological developments (Permanawati et al., 2018). However, some sources say that the skills that must be developed are not only critical- and creative-thinking skills, but also communication and collaboration skills. Both skills have an important role in the development of children's world.

In learning mathematics, collaboration skills have become an intake for both elementary and university students. However, it does not apply to communication skills. These skills are still considered very difficult to apply. Many educators consider that these skills are more suitable for language subjects only. In fact, communication is a tool or media for someone to interact with each other. According to Rustam and Ramlan (2017), communication is an important part of interpreting an idea and explaining a concept to someone. Communication is also a way for humans to go through the development process because good communication makes it easier for a person to overcome the problems around them. According to the 2017 National Education Regulation, reported by the Turkish Competencies Framework (TCF), communication skills are part of the education curriculum. Communication is a tool for mother tongue, the national language, and a means of delivering learning, as well as other competencies (Tican & Deniz, 2019).

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The Minister of Education and Culture Regulation No. 21 of 2016 concerning Content Standards for primary and secondary education units states that one of the skills targeted in mathematics learning is communication skills. There are four standard processes in mathematics as mentioned by the National Council of Teachers of Mathematics (NCTM), namely problem solving, reasoning, communication, and connection (National Council of Teachers of Mathematics, 2000). Based on these two, communication skills in mathematics are important to be mastered by students.

Communication in mathematics is often called mathematical communication. Mathematical communication is formed to encourage students to be able to express and share their ideas about mathematics. Mathematical communication skills can also affect many things including everyday life (Yaniawati et al., 2019). In terms of cognitive aspects, these skills are of use-value in mathematics learning, specifically increasing curiosity, that attracts and triggers students' interests during learning. Mathematical communication skills are shown in understanding mathematical concepts and procedures, the ability to represent these concepts, understanding some mathematical topics, and applying them in daily life.

The importance of mathematical communication skill aspects is not in line with the mastery of these aspects in Indonesia. From the results of the 2015 Trends in International Mathematics Science Study (TIMSS), Indonesia ranked 36th out of 48 countries (Mullis et al., 2016). Besides, the results of the Program for International Student Assessment (PISA) concerning students' mathematical communication skills, Indonesia also ranked 69th out of 76 countries (Organization for Economic Co-operation and Development, 2015). This is a sad reality because both indicated the low ranks. Weak mathematical communication skills of students are proven not only by the two organizations but also by the results of previous research. Teachers were still less successful in developing mathematical communication skills (Surya et al., 2018) because learning was teacher-centered, and the teacher did not have a choice of model as a material delivery strategy. Teachers still often implemented traditional learning models. Besides, the results of other research also mentioned that the mathematical communication skills of students in Indonesia are not good yet. As a result of in-depth analyses from the mathematics development center, Indonesian teachers have difficulty developing problem-solving skills in their students and find it difficult to transform mathematical problems into appropriate learning models (Yulian, 2018). This is a new indication that communication skills and mathematical problem solving among students are still low.

Mathematical communication skills can be improved through meaningful learning processes, one of which is by implementing an innovative and Problem-Based Learning (PBL) model. Some previous research has examined the effects of learning models on students' mathematical skills. Ardiyani et al. (2018) have analyzed the effect of the use of the Realistic Mathematics Education (RME) model on the students' mathematics learning outcomes. The research proves that the Student Teams Achievement Division (STAD) model with the RME approach is superior to the Think Pair Share (TPS) model with the RME approach. Besides, the RME approach can also increase students' learning activities and motivation. On the other hand, Trisnawati et al. (2018) explain that the application of mathematical learning models with the RME approach can improve students' mathematical communication skills. The characteristics of this approach are relevant to the context of the proposed problem, mathematical models, the process of student interaction, and the integration of the subjects studied. Through this, students can easily follow the learning process well.

In addition to the RME approach, some research has also examined innovative learning models such as the Problem Posing (PP) model in mathematics learning. The framework of this model includes abilities that show students' knowledge and explanations in problem-solving, such as when students assess their metacognitive processes (Pittalis et al., 2004). The PP is a learning model that facilitates students in creating many problems from the information obtained to be solved immediately (Retnowati et al., 2018). The problem is related to problems of daily life (Unver et al., 2018). The results of the research prove that there is an interaction between learning models and strategies. It was found that PP is more effective than PBL, but it is more suitable in group learning (Ersoy, 2016). The PP model has also been tested quantitatively with positive results. This model is recommended for PBL and influences student confidence (Ozgen & Bayram, 2019).

Besides, the research conducted by Calabrese et al. (2019) concluded that the application of PP can influence elementary school students' mathematics learning achievement. The learning was conducted with games in the classroom so students felt happy and motivated to learn again. Furthermore, students could gain much experience. When the students used mathematics relevant to their personal lives, they began to understand the purpose of learning mathematics. On the other hand, the results of other studies show the data that the achievement of students' mathematical communication skills in the experimental class is better than that in the control class after the application of PP (Mulyasari et al., 2018). The development of mathematical communication skills of the students who learn with PP increases drastically or significantly. Many stages can be done by students, one of which is a structured problem-solving. Through the steps of PP, students are more confident in solving various mathematical problems, both oral and written delivery. This is supported by the opinion of Rosli et al. (2014) which revealed that there were positive influences during PP learning. Students get many benefits, such as improved learning outcomes in mathematics, improved problem-solving abilities, and improved attitudes or learning styles during mathematics learning.

However, in reality, not only external factors such as learning models but also many other factors affect students' mathematical communication skills. Vale and Barbosa (2017) mention these factors as learning motivation and statements of interest in mathematics. In addition to these two factors, learning activities also influence students' communication skills, as revealed by Triana et al. (2019). In line with this opinion, Nurfadhillah et al. (2018) also mention the class activities and instruments used to influence students' mathematical skills. The right instrument will truly represent the ability of students.

In this research, the researchers examined the cognitive style factor on students' mathematical communication skills because cognitive styles function as a process of organizing information and a tool to predict the abilities of each individual (Mello & Rentsch, 2014). Cognitive styles are also a way for each individual to think and make a choice (Udiyono & Yuwono, 2018). Much research has used cognitive styles as a research variable with university students as the subjects, as done by Brown et al. (2019). They chose students to be participants in their research. Toomey and Heo (2019) also used students as research samples. Besides, research was also conducted on junior high school students. It was conducted in two schools using a mixed-method approach (Fajriyah & Asikin, 2019). They researched online surveys. Meanwhile, Prayekti (2016) experimented with a model in senior high school students. He chose a quantitative approach to do his research.

Some research about PP or RME learning models, cognitive styles, and mathematical communication skills has been conducted. However, there was no research on elementary school students. Some researchers prefer students who already have high abilities, such as senior high school to university students. Most of them are aged 15 to 24 years. This age is recognized as having high mind power, especially communication skills. This is reasonable because they have experienced a lot, so it is not surprising that their knowledge is more than those under 15. In contrast, elementary school students need the help of many parties. They are less able to be independent in learning, so they become a priority in developing mathematical communication skills. Elementary school students have more opportunities to speak, write, and draw through learning mathematics. Many math assignments facilitate students to prove their correct answers without rational explanations so that many of them know the answer but do not know the completion process (Lee, 2015).

Previous research has also analyzed the cognitive style. Huertas et al. (2016) explained that cognitive style refers to the way individual habits process information. This condition helps teachers in developing student assignments. Furthermore, Yonker et al. (2016) revealed that there was a relationship between cognitive style with analytical thinking. This analytical thinking leads to solving problems that exist in the daily lives of students. In line with the previous opinion, Martinsen and Furnham (2019) argued that the implementation of experiments on students regarding the cognitive style and motivation of students has created different learning situations. Many students can better develop themselves in creative problem-solving. The cognitive style also plays an important role for students, especially self-motivation in completing their assignments. A study examining the effect of cognitive style with the gender on problem-solving skills has proven that there are significant effects of cognitive style and gender (Mefoh et al., 2017). Teenagers who have independent cognitive styles can accomplish more tasks than those with dependent cognitive styles. When viewed from gender, it appears that men are superior to solving problems from women.

From several previous studies, there have been many reviews about cognitive style. However, there has not been any association between cognitive style and students' mathematical communication skills. Given this, research will be more different because the cognitive style has an important role in developing students' written mathematical communication skills (WMCS). Student's cognitive style will provide an important picture for teachers about how students obtain and process information. The thing or knowledge that the students get will be a new thing for them, and the students have an absolute right to express it, especially in the communication process. Many students find it easy to convey ideas verbally, but this ability does not guarantee that they have communication skills in a written form. The correlation between these two things becomes more interesting because they complement each other. Cognitive style is related to the process of acquiring and processing information of students with the form of delivery of the acquisition of the information.

Some models have indeed provided many benefits such as a creative problem-solving model, problem-based learning, and the like. However, the selection of the PP model with the Indonesian Realistic Mathematical Education (IRME) approach can be the right choice to reach the level of students' WMCS influenced by other factors (cognitive style).

Based on the explanation above, the novelty of this research is to test the effectiveness of the PP learning model with the IRME approach and PP learning model on the Written Mathematical Communication Skills (WMCS) of elementary school students. This research specifically aims to test (1) the effectiveness between the PP model with the IRME approach and the PP model on the WMCS, (2) the effectiveness between the Field Independent (FI) and Field Dependent (FD) cognitive styles on the WMCS, (3) the effectiveness of between the PP learning model with the IRME approach and the PP model on the WMCS from each cognitive style, and (4) the effectiveness between FI and FD cognitive styles on the WMCS from each learning model.

Methodology

Research Goal and Design

This research was conducted to test the effectiveness of the PP learning model with the IRME approach on the WMCS viewed from students' cognitive styles. The quantitative research method with a quasi-experimental design was used. This method was chosen because the independent variables used are difficult to control. The researchers wanted to see whether the results of treatment conducted by the teachers through the pre-test and post-test showed a positive effect or not. This reasoning is consistent with the opinion that the quasi-experimental approach aims to find out how researchers try to control variables so that the independent variables give effect to the dependent variable (Lodico et al., 2006).

This research employed a 3 x 2 factorial design. The independent variable in this research is the learning models, the dependent variable is the WMCS, and the intervening variable is the cognitive styles. The learning models used are the PP learning model with the IRME approach, PP, and the Direct Instruction (DI) learning model. There are two intervening variables, namely FI and FD cognitive styles.

Table 1. Research Design

Cognitive Styles / Learning Models	Independent (B_1)	Dependent (B_2)
PP Model with IRME (A_1)	A_1B_1	A_1B_2
PP Model (A_2)	A_2B_1	A_2B_2
DI Model (A_3)	A_3B_1	A_3B_2

Research Hypothesis

The research hypotheses include:

1. Learning with the PP model with the IRME approach provides students with better WMCS than learning with PP and DI models, and learning with the PP model provides students with better WMCS than learning with the DI model.
2. WMCS of students with FI cognitive style are better than WMCS of those with FD cognitive style.
3. The PP learning model with the IRME approach will improve the WMCS of both FI and FD students. PP and DI learning models will provide better WMCS to FI students than to FD students.
4. Students with FI cognitive style will have better WMCS when learning with the PP model with the IRME approach than those learning with PP and DI learning models. The use of the PP learning model will provide students with better WMCS than the use of the DI model. Students with FD cognitive style will have better WMCS when learning with the PP learning model with the IRME approach than those learning with PP and DI learning models. The use of the PP learning model will provide better WMCS than the use of the DI learning model.

Sample and Data Collection

The research population included all fifth-grade students of elementary schools in Jebres District, Surakarta City in the 2019/2020 academic year. The sample consisted of nine classes from nine elementary schools in Jebres. The stratified random sampling technique was performed. Stratified random sampling is the selection of samples by considering the strata in each class so that each sub-group can be represented correctly (Lodico et al., 2006).

The strata used are based on the latest national exam results. Based on these results, elementary schools in Jebres were divided into three categories of high, medium, and low. From each category/ level, three schools were taken as the sample randomly. At each level, the schools were selected randomly to determine the experimental class 1, experimental class 2, and control class.

For the high-category schools, Bulukantil Public Elementary School was chosen as the experimental class 1 with a total of 41 students, Sibela Timur Public Elementary School was chosen as the experimental class 2 with a total of 32 students, and Purwodiningratan Public Elementary School was chosen as the control class with a total of 27 students. For the medium-category schools, Mojosongo 5 Public Elementary School as the experimental class 1 with 30 students, Kendalrejo Public Elementary School as the experimental class 2 with 24 students, and Sanggrahan Public Elementary School as the control class with 17 students. For the low-category schools, Mojosongo 2 Public Elementary School as the experimental class 1 with a total of 29 students, Ngemplak Public Elementary School as the experimental class 2 with 27 students, and Purwoprajan 1 Public Elementary School as the control class with 13 students. Therefore, the total number of samples is 240. The instruments used included cognitive style and written mathematical communication skill test instruments. The cognitive style test instrument is called the Group Embedded Figures Test (GEFT). The GEFT instrument consisted of 25 questions in the form of pictures with three parts. The first part consisted of 7 questions. This section was used as an exercise for students. The second and third sections consisted of 9 questions each. The second and third parts became the consideration in this research. The GEFT instrument consisted of complex and simple pictures. These simple pictures would be searched and thickened by the students. The students are classified to have the FD cognitive style if the scores obtained are between 0-11 and the FI cognitive style if the scores are between 12-18.

The student's written mathematical communication skill test instrument is presented in the form of an essay test. This instrument consisted of two types, namely pre-test and post-test instruments. Each instrument consisted of five questions. The indicators of WMCS are (1) connecting concrete objects in the form of mathematical models (pictures and tables), (2) explaining mathematical models (pictures and tables) into own languages, (3) asking questions about mathematics that have been learned using own language, (4) stating daily problems or events in mathematical models, and (5) constructing arguments using own language (Warli & Fadiana, 2015).

The most important thing in quantitative research is the instrument used to collect data because the instrument is used to obtain scores. The scores will be analyzed to determine the effectiveness of the model being experimented. Therefore, the instrument used must be valid and reliable.

The instrument validity test in this research was carried out with expert judgment and field trials. This expert judgment was to produce an easy-to-use instrument. The field trials were to determine the objectivity level of an instrument so that the researchers could analyze more deeply the results of the instrument made.

In the expert validity test, the GEFT instrument was assessed by three experts with doctorates. The experts consisted of one linguist lecturer and two counseling professors. Meanwhile, the written mathematical communication skill test instrument was assessed by two lecturers from mathematicians, one lecturer from linguists, one lecturer from evaluation experts, and one teacher from field practitioners.

The three instruments that had been revised and declared valid by the experts were then tested in the field. The written mathematical communication skill test instrument was tested on the fifth-grade students of elementary schools. The class used for the instrument trial is outside the sample but is still within the scope of the research population.

The trials of the GEFT instrument were carried out in 5A of the Sibela Timur Public Elementary School with a total of 30 students and in 5A of the Mojosongo 5 Public Elementary School with a total of 26 students to see the readability of the instrument for the fifth-grade students as it is a standardized instrument. Therefore, the validity of the instrument is known from the readability of the instrument at the level of the research sample.

Based on the results of the trials on 56 students, it is evident that 30 students fall into the FI category and 26 into the FD category. The trial results prove that the GEFT instrument is readable for students who have the same character and age as the research sample. Thus, this GEFT instrument is and can be used in research.

Furthermore, the written mathematical communication skill test instrument that had been declared valid by experts was tested in the field. The pre-test and post-test instruments consisted of 10 questions representing five indicators of WMCS. The results of the field trials were analyzed using MS Excel. The instrument validity test results were calculated using the Pearson's Product Moment formula, while the reliability test results were calculated using the Cronbach's Alpha formula (Gower & Shanks, 2014). The material used for the pre-test was the material that had been studied by the students (before the material subject to treatment). The pre-test instrument was tested on 64 fifth-grade students in Lukman Hakim Integrated Islamic Elementary School.

The validity value of r for 64 students is 0.32. A problem is valid if $r > r_{table}$. Based on the calculations, the valid items are numbers 2, 4, 5, 6, 8, 9, and 10. The valid questions include question numbers 1, 3, and 7. An instrument is said to be reliable if $r_{11} > 0.70$. Based on the calculation of the reliability of the pre-test instrument, $r_{11} = 0.72$ was obtained. The discrimination power in each pre-test question has a range between 0.2 - 0.7. Therefore, the problem is included in the category of very good discrimination power. As for the results of the calculation of the level of difficulty, the score obtained is 0.2 - 0.2. Thus, the questions in the pre-test are of easy to moderate levels of difficulty. Based on the calculations and consideration of the four factors, the items to be used in the research were questions 2, 5, 6, 8, and 9.

The trial of the written mathematical communication skill post-test instrument was conducted at the Muhammadiyah 6 Jagalan Elementary School. There were 85 students in the pilot classes. The validity value of r for 85 students is 0.278. Based on the results of the analysis, there were eight valid and two invalid test items. The reliability of the post-test instrument was 0.74 which means that $r_{11} > r$. The results of the analysis on the level of difficulty range between 0.2 - 0.6, so that the test items are of the moderate to difficult category. The discrimination power is between 0.06 - 0.6 of the bad to good category. Based on the results of the trial analysis, the items used in the post-test are 1, 3, 6, 8, and 10.

Analyzing of Data

The research data analysis was performed with descriptive statistics, prerequisite, hypothesis, and Scheffe tests using MS Excel. The researcher used several formulas in the completion of the data analysis, such as validity calculation using Karl Pearson's product-moment formula, reliability calculation using Cronbach's alpha's formula, mean, normality, homogeneity, and two-way ANOVA test using two factors with replication, and several other formulas.

The data prerequisite tests in the quasi-experimental research include normality and homogeneity tests. The normality test was carried out using the Lilliefors method. The data are normal if $L_0 < L_{table}$. The homogeneity test was done by Bartlet test with Chi-Square test statistics. The data are said to be homogeneous if L_{obs} is less than L_{table}.

After the data pass the data prerequisite tests, they can be analyzed with parametric statistics. The formula used for the analysis is Two-Way ANOVA with Unequal Cells. Then, the data were further tested using the Scheffe analysis.

Before the analyses of the post-test prerequisite tests, the researchers conducted prerequisite tests for the pre-test instrument to determine the initial condition of the sample before getting the treatment. Based on calculations, the normality value of the PP model with the IRME approach is 0.087, while the calculation value according to the normality table is 0.089. This implies that the pre-test data of the PP IRME sample class is in a normal distribution. Then, the pre-test normality value of the PP model class is 0.094 with the PP model normality table data value of 0.097. Thus, the pre-test data of the PP sample class is in a normal distribution because the observed value is lower than the table value. The pre-test data of the DI sample class is in a normal distribution. It was known from the value of 0.111<0.117. After all the data had proven normal, they were analyzed for homogeneity. Based on homogeneity calculations, it can be seen that $\chi^2_{obs} < \chi^2_{table}$, 1.035 < 5.991.

Based on the calculation of normality and homogeneity, it has been proven that the pre-test sample data were normal and homogeneous. Therefore, data analysis could be continued by calculating the pre-test data balance test using the One-Way ANOVA with Unequal Cell formula. The decision-making technique is data is said to be in the same state if the observed F value is lower than the F table value. The F_{table} value of One-Way ANOVA with Unequal Cells is 3.034. The results of the calculations show that the value of F_{obs} is 0.457. Thus, the students' initial WMCS are of the same or balanced state because the observed F value is lower than the F table value.

Then, the researchers conducted data analyses using the two-way ANOVA test with unequal cells. However, before that, the data must meet the prerequisite tests first, namely normality and homogeneity tests. The data normality test results seen from the learning models are shown in Table 2.

Table 2. Normality Test of Written Mathematical Communication Skills Viewed from Learning Models

Learning Model	Observed Value	Table Value	Decision	Conclusion
PP IRME	0.076	0.089	H_0 is accepted	The sample comes from the normally distributed population.
PP	0.067	0.097	H_0 is accepted	The sample comes from the normally distributed population.
DI	0.085	0.117	H_0 is accepted	The sample comes from the normally distributed population.

The significance level (α) in this research is 0.05. Based on Table 2, the values of all observed F are lower than the F table value. Therefore, H_0 is accepted. Thus, it can be concluded is that from the learning models, the research sample comes from a normally distributed population. The data on normality based on students' cognitive styles are presented in table 3.

Table 3. Normality Test of Written Mathematical Communication Skills Viewed from Cognitive Styles

Cognitive Styles	Observed Value	Table Value	Decision	Conclusion
Field Independent	0.080	0.082	H_0 is accepted	The sample comes from the normally distributed population.
Field Dependent	0.075	0.080	H_0 is accepted	The sample comes from the normally distributed population.

Based on Table 3, it is known that the two F values are lower than the table F values, so H_0 is accepted. Therefore, from the cognitive styles, the research sample comes from a normally distributed population. Then, homogeneity test results are presented in Table 4.

Table 4. Homogeneity Test of Written Mathematical Communication Skills

	Observed Value	Table Value	Decision	Conclusion
Learning Model	4.342	5.991	H_0 is accepted	Variants of the three learning models are the same (homogeneous)
Cognitive Styles	3.554	3.841	H_0 is accepted	Variants of the two cognitive styles are the same (homogeneous)

Table 4 shows that the observed values of the learning models and cognitive style are lower than the table value, so H_0 is accepted. Thus, it can be concluded that the variances of the three learning models and both cognitive styles are the same or homogeneous.

Findings/Results

This research aims to find out the effectiveness of the PP learning model with the IRME approach (PP IRME) on WMCS viewed from cognitive styles in fifth-grade students of elementary schools. The results of the WMCS central tendency size based on the learning models can be seen in Figure 1.

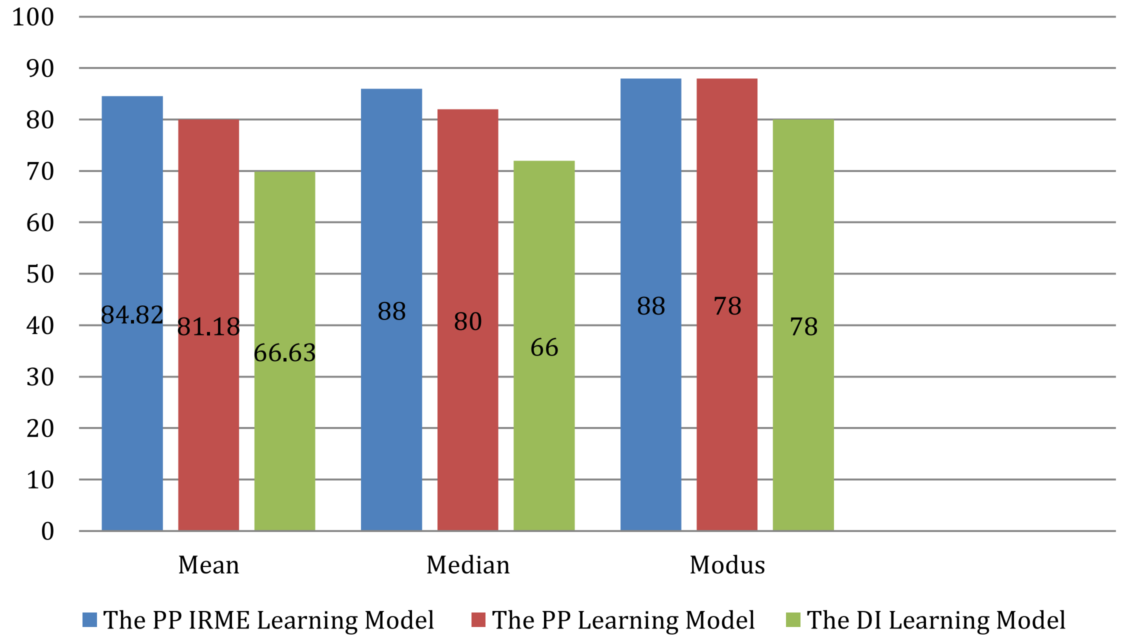

Figure 1. Comparison of Scores in Each Learning Model

The information obtained from Figure 1 is that the PP IRME learning model is the most effective compared to the other two models. When viewed from the mean, median, and mode displayed, it is visible that the PP IRME learning model is better than the PP and DI models, while the PP learning model is better than the DI model.

The results of the research had been analyzed to calculate normality and homogeneity tests. From the calculation results, it is clear that the samples were normally distributed and homogeneous. Therefore, the researcher conducted an ANOVA test as a step to determine the effect of learning models on students' WMCS viewed from cognitive style. The results of the analysis are shown in Table 5.

Table 5. Summary of Two-Way ANOVA with Unequal Cells

Source	Number of Squares	Degrees of Freedom	Average Square	The Result of Statistics Test	Critical Limit	Decision
Learning Model	13578.098	2	6789.049	100.746	3.03	H_{0A} is rejected
Cognitive Styles	1907.936	1	1907.936	28.313	3.88	H_{0B} is rejected
Interaction	420.878	2	210.439	3.123	3.03	H_{0AB} is rejected
Error	15768.812	234	67.388	-	-	-
Total	31675.724	239	-	-	-	-

The decision-making technique in the two-way ANOVA with unequal cells is if the observed value is more than the table value, then H_0 is rejected. Based on Table 5, it is known that all observed values more than table values. Thus, it can be stated that all H_0 are rejected. Thus, we can conclude as follows:

1. There are differences between the three learning models used on the WMCS of the fifth-grade students of elementary schools.
2. There are differences in WMCS between students who have FI and FD cognitive styles.
3. There is an interaction between learning models and cognitive styles with WMCS.

Then, the data were analyzed using the Scheffe Advanced Test. It was conducted to test the comparison between learning models (rows), as well as interactions between learning models and cognitive styles (cells). Comparisons between columns are not made because there are only two elements in the cognitive style variable, FI and FD. What to do is to compare the marginal mean values of the cognitive styles. The marginal mean of the WMCS based on learning models and cognitive styles can be seen in Table 6.

Table 6. Marginal Mean of Written Mathematical Communication Skills

Learning Model	Cognitive Styles		Marginal Mean
	FI (B1)	FD (B2)	
PP IRME (A1)	85.83	83.89	84.86
PP (A2)	84.74	77.10	80.92
DI (A3)	70.74	62.93	66.84
Marginal Mean	80.44	74.64	-

Based on Table 6, the marginal mean marginal value between the FI cognitive styles is greater than that of the FD cognitive style, meaning that the WMCS of the students with the FI cognitive style are better than those with the FD cognitive style. Then, the results of multiple comparisons or the Scheffe test (learning model) can be seen in Tables 7 and 8.

Table 7. Summary of Between-Row Double Comparison (Learning Model)

Hypothesis	The Result of Statistics Test	Critical Limit	p
μ(A1) = μ(A2)	10.432	6.068	< 0.05
μ(A2) = μ(A3)	99.485	6.068	< 0.05
μ(A1) = μ(A3)	174.983	6.068	< 0.05

The significance level used is 0.05. The decision-making technique is if the observed value > the value of the critical region, then H_0 is rejected. Based on the data display in Table 7, all three H_0 are rejected. Therefore, we can conclude as follows:

1. There are differences in WMCS between students taught by the PP IRME model and the PP model. When viewed from the marginal mean of the WMCS between the PP IRME and PP models, it is known that the PP IRME model is more effective because the mean of the WMCS of the PP IRME model is greater than the PP model that is 84,86 > 80,92.
2. There are differences in WMCS between students taught by the PP model and by the DI model. When viewed from the marginal mean of WMCS between the PP and DI models, it is known that the PP model is more effective because it has a greater mean than DI that is 80,92 > 66,84
3. There are differences in WMCS between students taught with the PP IRME model and the DI model. When viewed from the marginal mean of the WMCS between the PP IRME model and DI model, the PP IRME model is more effective because it has greater mean than the DI model that is 84,86 > 66,84.

Table 8. Summary of Between-Cell Double Comparison

Hypothesis	The Result of Statistics Test	Critical Limit	p
μ(A1B1) = μ(A1B2)	1.407	11.263	> 0.05
μ(A2B1) = μ(A2B2)	17.969	11.263	< 0.05
μ(A3B1) = μ(A3B2)	12.854	11.263	< 0.05
μ(A1B1) = μ(A2B1)	0.399	11.263	> 0.05
μ(A2B1) = μ(A3B1)	48.264	11.263	< 0.05
μ(A1B1) = μ(A3B1)	58.410	11.263	< 0.05
μ(A1B2) = μ(A2B2)	15.443	11.263	< 0.05
μ(A2B2) = μ(A3B2)	51.055	11.263	< 0.05
μ(A1B1) = μ(A1B2)	123.922	11.263	< 0.05

The decision-making technique in Table 8 is the same as in Table 7, which is if the observed F value is greater than the F table, then H_0 is rejected. Based on Table 8, the conclusions that can be drawn are as follows:

1. Students with FI and FD cognitive styles taught with the PP IRME model obtain equally good WMCS, different when taught with the PP and DI models. Based on the mean in Table 8, it is known that the value of students' WMCS taught by the PP model is better than with the DI model.
2. Students with the FI cognitive style taught with the PP IRME and PP models will have better WMCS compared to those taught with the DI model. In addition, students taught with the PP IRME model have the same WMCS as those taught with the PP model.
3. Students with the FD cognitive style have different WMCS when taught with all the three models. Based on the mean in Table 8, it can be concluded that the WMCS of the students are better when taught with the PP IRME rather than the PP and DI models. PP model can improve the students' WMCS better than the DI model.

Discussion

More Effective Learning Model on Improving Written Mathematical Communication Skills

Based on the analysis that has been done, it is known that the PP IRME learning model is more effective than the PP and DI learning models, and the PP learning model is more effective than the DI model in increasing students' WMCS. This is because the PP IRME model can facilitate students to actively participate in problem solving. The effectiveness of the PP IRME model is in line with some previous research. The previous research has reviewed that the Realistic Mathematics Education (RME) approach could increase the minimum completeness criteria to the maximum (Rahman et al., 2018). They chose junior high school students as the research subjects. However, the researchers used the elementary school students as the recipients of treatment. The understanding between elementary school students and junior high school students is clearly different. It is caused by several factors, such as the material being studied, the background of students, and the ability of teachers to transfer their knowledge to students. This cannot be separated from the teacher's role in developing students' WMCS.

In addition, the advantage of the IRME approach to increase mathematical skills has also been proven by Mahendra et al. (2017) and Laurens et al. (2018). They prove that through this approach, students have better abilities in understanding conceptual mathematics than through the DI model. IRME approach has a more detailed concept of learning. This approach is also known as the development of the RME approach. Judging from the name of the approach, it can be interpreted that learning is done in real or more on things that are contextual and related to student life. Thus, students have more natural understanding because it is in line with their daily lives.

Other research on the results of IRME and Define Assess Plan Implement Communicate (DAPIC) approaches to problem solving can also improve students' mathematical literacy better than the control class (Sumirattana et al., 2017). Their research explains that students' mathematical literacy skills while attending IRME learning are better than before. Enthusiasm in learning and understanding of student literacy increases with the progress of learning in class. However, this is also caused by teachers who strongly support learning with various learning tools. Some mathematics learning outcomes of students taught with the RME approach are better than those taught with a scientific approach. Astuti et al. (2020) also explains that the level of mathematical communication skills has an influence on mathematics learning outcomes, meaning that students with high mathematical communication skills will have high mathematical learning outcomes and vice versa.

Learning with the PP method has been done by several previous researchers. This model is problem based. In fact, this model allows students to focus on problem solving. Yuberti et al. (2019) have conducted research on a problem-solving approach with a quasi-experimental method. They found that the problem-based approach can develop students' communication skills and comfort in learning. Not only that, this model is also able to help students in conceptual-based learning.

Several explanations from previous research has proven that PP model with IRME approach helps students achieve better WMCS than the DI model. This is in line with the results of this research.

More Effective Cognitive Style on Improving Written Mathematical Communication Skills Based on the results of the research, it is known that the FI cognitive style gives a better effect on WMCS than FD because students with the FI cognitive style implements learning rules appropriately. They can understand the learning objects well, create a conducive learning atmosphere, and remember parts of the material well. Cognitive style can not be separated from the encouragement of teachers and parents. The concept of learning that is well planned in class will become a good habit for students in developing their cognitive styles. In the end, students will be able to control themselves to reach higher levels of thinking, such as critical and creative thinking. Not only that, students will also be able to manage their communication skills well.

It is also supported by the results of the previous research which says the same. Students with the FI cognitive style have better critical-thinking skills than with FD (Kadarsono et al., 2019). They can conclude, assume, provide information, and interpret a problem correctly. Meanwhile, students with the FD cognitive style cannot interpret a problem well. They need help from the teacher to trigger the students to respond. The findings were also expressed by other researchers. The FI cognitive style of students in tertiary institutions reflects an independence, discipline, self-control, and anticipation of a problem (Masalimova et al., 2019). From this finding, the researchers compared the cognitive styles and strategies carried out by the younger generation in problem solving and the results proved that the FI cognitive style had a positive effect on their life.

Students who have the FI cognitive style are more likely to be unaffected by environmental objects. They prioritize the ability to process information independently even though it is not in accordance with the reality. In addition, they are also able to analyze and more systematically receive information from the environment (Gibelli et al., 2019). The results of another research revealed by Warli and Fadiana (2015) explained that the mathematics learning model accommodates reflective and impulsive cognitive styles. These accommodations result in the development of problem-solving skills. Overall, through cognitive style and the use of PBL model can strengthen students' mathematical understanding and development of problem solving.

However, the results of this research are not all supported by much previous research. There is one research that refutes. Setiawan et al. (2020) say that students with the FD cognitive style can perceive a test pattern presented in the form of pictures to be narrower, without considering the existing picture structure. Students can reduce mistakes made and generalize problem-solving strategies wisely. Thus, it was found FD is better than FI. In relation to WMCS, students with the FD style have problems in writing a solution (Luo, 2019). They need help and motivation from their peers and teachers.

More Effective Learning Model on Improving Written Mathematical Communication Skills in Cognitive Styles

The results show that from the FI and FD cognitive styles, learning using the PP learning model with the IRME approach is as effective as using the PP model, but more effective than DI, and the PP learning model is more effective than the DI learning model. The effectiveness of the PP learning model with the IRME approach of the other two models has been proven before. This is reasonable because this model gives students the opportunity to explore themselves freely. Through this model, students' mathematical skills are more visible, especially the process of mathematical creativity in problem solving (Nuha et al., 2018). The teacher only functions as a facilitator in learning. When compared with the PP learning model without being accompanied by IRME approach, the students seem to have enough good motivation to learn. Class situation is conducive. Students get an unusual learning experience. The activities of problem solving are interesting for students. Students can complete several test items well. This is like the research results of Cai et al. (2019) showing that some teachers felt they were more familiar with the steps of the PP learning model during mathematics learning. After conducting the workshop, the teacher applied the model to elementary school students. The results were quite satisfying. More than 80% of students obtained maximum results in learning mathematics. The use of the PP learning model shows useful learning activities, especially in the mathematical achievement, problem-solving skills, peak problem solving, mathematical attitudes for students. Rosli et al. (2014) suggest making policies to apply innovative models in mathematics learning so that learning is more meaningful. This will help the teacher develop students' knowledge and skills.

Furthermore, Turmudi and Maulida's research (2019) produced data that through a quantitative approach with a quasi-experimental method, the PP model and the RME approach were proven to be effective in increasing students' mathematical communication and problem-solving skills The teacher managed to change students' perceptions about mathematics. The students considered mathematics as a difficult subject. Through the PP model with the RME approach, they have many solutions to solve mathematical problems. This approach also contributes to students so they can have learning motivation and good learning attitudes. When compared with the use of the DI model, the results are very much different. Students learning with the DI model show an attitude of boredom and are not eager to learn so that their learning outcomes are the same or do not improve. Some experience a decline in their learning outcomes.

The advantage of the PP model with the IRME approach has been proven. This model cannot be likened to the DI learning model. The DI model only gives instructions directly to students. It cannot develop the students' skills well. Some research results also prove the same thing. Lukman (2017) writes that the mean of students who learn using the Think Talk Write (TTW) model is higher than using the conventional model. The difference between the two models is not high enough. However, they explain the real differences during treatment. The use of the conventional model is only suitable when the material being studied is conceptual and has a lot of material coverage. Thus, it is not surprising that the expected results are lower than of other innovative models. In addition, the results of the research between the DI and Multimedia Instruction models implemented by senior high school students have different effects (Azimigaroosi et al., 2015). The DI model is more suitable to be applied in learning that teaches student performance, while the Multimedia Instructional model is better applied to develop the students' potential in technology.

More Effective Cognitive Style on Improving Written Mathematical Communication Skills in Learning Model

A double comparative analysis of better cognitive styles for each model has been done. The results illustrate that the FI cognitive style is more dominant than FD in various learning models. However, this does not apply to the PP learning model with the IRME approach. These results are caused by many factors. Empirically, students with the FI cognitive style display positive attitudes in learning. Many things are done by the students during the learning process. They can follow the learning well because they have a high willingness to learn. This is unlike the students' responses to the FD cognitive style, in which they still depend on the teacher's instructions. Student independence has not yet emerged. The empirical data are accurate evidence that students have FI more than FD learning styles. These data are supported by the results of the previous research showing that the learning outcomes of problem solving and mathematical communication skills of students with the FI cognitive style are better than with FD (Setyosari et al., 2016). They assume that students who have the FI cognitive style can accept and understand the problems given by the teacher more quickly. They are responsive and agile. However, this result only applies to FI students who are subjected to innovative learning models. For students who are subject to the DI model, they did not show significant changes in mathematical problem solving.

The process of mathematical communication of students is not far from the way they think creatively. This process involves several steps, one of which is problem posing as a model. Other processes are also carried out such as orientation, preparation, incubation, and verification. These steps are outlined in the stages of the RME approach. From these activities, it has been proven that the RME approach facilitates students' way of thinking (Sitorus, 2017). In line with this opinion, Nuraida and Amam (2019) also explain in their research that the RME model can develop students' mathematical communication skills. In mathematics learning, the use of the RME model or better known as IRME is done to solve problems that are contextual or from real situations. Thus, students can communicate what they learn about mathematics well, both in writing and orally.

The results of other research reveal that the PP model experimentation make students more active and give a positive response to the classroom situation than the experimentation on conventional learning models (Anim et al., 2019). When viewed from students' cognitive styles, the two innovative models experimented (PP with IRME and PP approaches) can actively stimulate students in the FI category. Information presented on the effectiveness of the PP model is also felt by other researchers, such as Sari and Surya (2017). The percentage of the students' scores are very good. In addition, the activities of students and teachers are also well established because of the close relationship between them.

However, in reality the PP model does not always have a positive effect on students' learning outcomes. This is because from the results of research conducted by Christidamayani and Kristanto (2020), it is concluded that the PP model is more functioning or has a positive effect on student motivation. The results of the analysis show this model has an impact on students' interests, enthusiasm, collaborative attitudes, and self-control. The results also contradict the previous research by Rohim and Umam (2019) showing that the PP model is no more effective in increasing students' mathematical communication skills. Another more effective model was found after conducting experiments on junior high school students.

Based on the explanation above, PP learning model with IRME approach proved to be more effective than the direct instruction model for students' WMCS in terms of cognitive style. FI cognitive style can improve WMCS better than FD cognitive style in all learning models. Both PP learning model with IRME approach and the direct instruction model provide opportunities for students with FI cognitive style to optimize themselves (Sudarman et al., 2016). Students have the opportunity to learn and discover their own material concepts, as well as to get independent learning resources and materials. They give their own learning priorities and are able to make summaries and concept maps of the material they learn. On the contrary, students with cognitive style need help and guidance from teachers to be more motivated to learn. The teacher must explain the material clearly and determine the strategy before delivering the material. In general, PP learning model with IRME approach can improve students' WMCS based on each student's cognitive style.

Conclusion

Based on the results of the research and discussion, some conclusions can be drawn. First, the PP learning model with the IRME approach is more effective than the PP and DI models for WMCS. Second, students with the FI cognitive style have better WMCS than those with FD. Third, the PP model with the IRME approach is as effective as the PP model, but more effective than the DI model in students with FI cognitive styles, and the PP model is more effective than the DI model in students with FI and FD cognitive styles. Fourth, in the PP learning model with the IRME approach, students with the FI cognitive style the same skills as with FD. However, the students of FI cognitive style have better skills than those with FD cognitive style when learning with the PP and DI learning model.

Suggestions

The implementation of the research has a far better effect than the previous treatment. The use of the PP model with the IRME approach is proven to contribute to the achievement of WMCS of elementary school students. With this in mind, the principal can make a written policy in his school to apply the PP model with the IRME approach to the mathematics subject. This policy is aimed at teachers as the learning implementer in schools. Besides the effectiveness of the learning model, cognitive styles have also been proven to influence students' WMCS. However, it appears that FI is superior to FD. Therefore, teachers should be able to balance these two types of cognitive styles well through independent learning or the application to Teacher Competency Activities (KKG). KKG can be used by teachers to share information about the needs and management of students' cognitive styles. Regional governments can also create a program on developing WMCS and cognitive styles that are accommodated in workshops or structured socialization in each region. This research has positive effects on not only WMCS, but also on critical-thinking skills and student motivation. Thus, other researchers can re-experiment critical-thinking skills or develop WMCS instruments in the future. Other developments will increase theoretical studies on WMCS, cognitive styles, or other innovative learning models.

Limitations

This research has some limitations, including (1) the research was carried out on elementary school students, (2) the scope of the area is quite narrow because there is only one district, (3) the model applied is limited to the problem-based learning model, and (4) the material learned is only elementary school mathematics.

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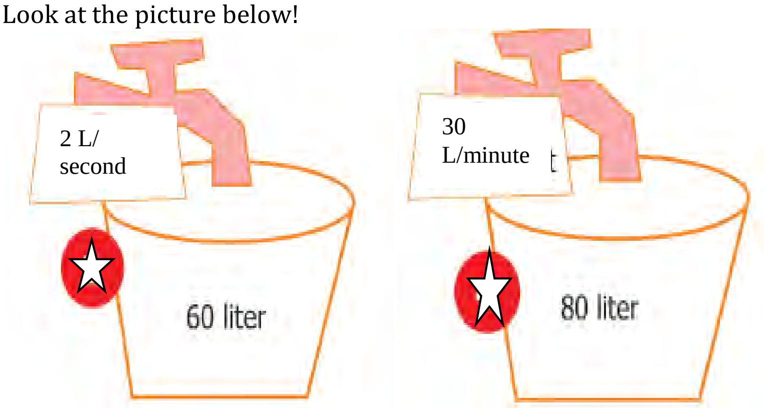
Appendix

Do the questions below carefully!

1. A water tank contains 250 dm^3 of water. Mr. Jamil used it to water the grass using a hose. He watered the grass from 8:00 to 8:50 a.m. The remaining water is 10 liters. What is the discharge of the water hose?

2. Edo will go to the market by motorcycle with a speed of 50 meters/minute. His house is 6 km away from the market. Edo leaves for the market at 7:00 a.m.
   a. Can Edo arrive at the market at 8:00 a.m.?
   b. Explain your reason!

3. Look at the picture below!



A B

Write down the information you obtain from the picture above!

4. Read the text below!

   Mr. Hendi went to the office at 6:30 a.m. and arrived at 8:30 a.m. He went to the office by a motorcycle. The distance of his house to the office is 60 km.

   a. Make questions based on the text above!
   b. Answer the questions that you have made!

5. Read the text below!

   Dayu rode a large boat from the K island dock to the L island with a speed of 120 km/h. He traveled 30 km in 15 minutes. Meanwhile, Deni traveled from the M island dock to the N island, which is 30 km away, by a small boat with a speed of 60 km/h for 30 minutes.

   Make a table based on the data above!