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Comparison of Problem-Based Learning Model with Direct Instruction in Mathematics Learning Towards the Development of Critical Thinking Skills

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ABSTRACT: The selection and application of learning models to develop critical thinking skills is a problem in learning mathematics in elementary schools. The purpose of this study was to determine the difference between Problem Based Learning model and Direct Instruction model in mathematics learning on the development of critical thinking skills. This research is a quasi - experimental research, using quantitative data analysis and sampling using cluster random sampling. Data collection with tests. Data analysis of this research includes: prerequisite analysis test, two-way variance analysis test of unequal cells, and further analysis of variance test. The results of the calculation of the analysis of variance test of two-way unequal cells obtained data that F_{count} (5.36) > F_{table} (3.91), and in the Anava further test, obtained data that the marginal mean of the Problem Based Learning model is 88.58 greater than the Direct Instruction model which has a mean of 80.05. The conclusion of the research is that the effectiveness of the Problem Based Learning model is better than the Direct Instruction model in developing critical thinking.

KEYWORDS: Critical thinking skills, Direct Instruction, Project Based Learning.

INTRODUCTION

Critical thinking skills are the focus of every learning objective that is useful for developing students. The importance of critical thinking leads to the need for an understanding of the notion of critical thinking skills. Critical thinking skills are needed to analyze a problem to the stage of finding a solution to solve the problem (Al Fanny and Roesdiana, 2020). Critical thinking skills are the ability to correctly conclude a problem, review and thoroughly examine the decisions taken (Larasati and Syamsurizal, 2022). Critical thinking skills are the ability to analyze arguments through aspects of finding basic similarities and differences in the material or learning topics studied (Erlistiani, et al., 2020). Meanwhile, another explanation states that critical thinking skills are the ability to tend to obtain information effectively, and then evaluate and apply it (Septarini & Kholiq, 2021). Based on the above description, it can be synthesized that critical thinking skills are the ability to analyze, conclude or find solutions, appropriately review a problem or learning topic by looking for basic similarities and differences in the material or learning topics studied.

Learners need to have critical thinking skills in following their learning. This is because the critical thinking skills possessed by learners can stimulate individual ways of thinking in order to optimize the potential ideas in their minds so that they can be well honed to solve certain problems (Ariadila, et al., 2023). The importance of having critical thinking skills provides benefits for students. The benefits of having critical thinking skills, namely: 1) Make it easier to assess an existing problem from a variety of different perspectives; 2) Have more innovative answers; 3) Occupy a position as a reliable partner; 4) Able to solve their own problems, 5) Have a wider level of probabillity.

Critical thinking skills are needed in the 21st century because critical thinking is thinking that is reasonable, reflective, and focused on deciding what to believe or do. Aspects of critical thinking include aspects, namely: 1) Elementary Clarification; 2) Basic for Decisions; 3) Inference; 4) Advanced Clarification; 5) Supposition and Integration (Ennis, 2011: 4-18). These aspects can be explained as follows: elementary clarification or brief explanation is described as the ability to analyze problems by connecting to knowledge concepts, so as to bring up several problem solving ideas; basic for decisions or having a basis for decision making is defined as the ability to connect various concepts that support the problem solving process and formulate problem solving; inference or the ability to draw conclusions is defined as the ability to draw conclusions based on several empirical experiences or experiences that can be measured by considering the concepts used; advanced clarification or the ability to provide advanced explanations is defined as the ability to provide arguments for the results of problem solving by providing definitions and concepts or theories that support problem solving; supposition and integration or the ability to estimate and combine, described as a form of ability to develop strategies to take action and detect these actions.

The goal of education in 21st century learning is the need for mastery of technology. Eggen and Kauchak. (2020: 27) explain that technology literacy has become a very important basic skill after reading, writing and arithmetic. This emphasizes that current learning needs to link the learning model with other knowledge. Linking between concepts has the aim of activating students to acquire the most basic abilities. These basic skills are: the ability and skill to question an aspect logically and solve problems (critical thinking and problem solving), the skill to build communication (communicative), the skill to make reciprocal relationships between others (collaborative), and the skill to find new things (creative).

The lesson that becomes the media in instilling and developing critical thinking skills in this study is mathematics. The results of observations, obtained data on the existence of misconceptions in building concepts, such as: mathematics learning is carried out using media at the beginning of introducing the lesson material, while when building mathematical formulas it leads to formal (abstract) learning. This can be seen from the results of explaining the meaning of fractional numbers 1/4. The teacher shows the media split into four separate ones as a form of 1/4 value, which should be 1/(1/4). Misconceptions that have been embedded in the mindset of students will last a long time. If this continues to happen, it will have an impact on errors in building and interpreting mathematical concepts and in developing critical thinking skills. Ojose (2015) states that: misconceptions are misunderstandings and misinterpretations that are based on false notions. Misconceptions can be long-lasting and can be very strongly held by students.

The importance and benefits of critical thinking skills for students, teachers should be able to choose and determine learning models that are able to develop them. Learning models that become references in learning mathematics in elementary schools are Problem Based Learning (PBL) models and Direct Instruction models. The problem-based learning model or PBL is a teaching and learning process that presents contextual problems so that students are stimulated to learn (Widiasworo, 2018: 149). PBL is problem-focused learning given before the learning process takes place and can trigger students to research, describe and find solutions to these problems (Amir, 2009: 65). Problem Based Learning (PBL) is a learning approach that places students in the context of solving real problems to encourage collaboration and skill development (Wardani, 2023). Based on this description, it can be synthesized that the Problem Based Learning (PBL) learning model is a learning model that focuses on solving problems by students, with the aim that students can think critically in researching, describing and finding solutions to these problems.

The PBL model has benefits in learning mathematics in elementary schools. Vebrianto et al. (2021: 73) explain that the benefits of the Problem Based Learning (PBL) model for students are: 1) Improve critical thinking skills, students are trained to analyze problems, find solutions, and evaluate results; 2) Improve problem solving skills, students are accustomed to facing real problem situations and finding creative solutions; 3) Improve the ability to work together, this learning model is often done in groups, so that students learn to collaborate and respect the opinions of others; 4) Increase learning motivation, students feel more involved in learning because the material being studied is relevant to real life; and 5) Improve communication skills, students practice conveying ideas and arguments effectively. Based on the description of the benefits above, the PBL model provides space to develop critical thinking skills.

The learning model has stages in its learning. Arends (2012: 397) explains that the stages in implementing the PBL model, namely: students are oriented to the problem; students are organized to learn; investigations are carried out individually and in groups; create and present products or works; and conduct analysis and evaluation of the problem-solving process. Meanwhile, Kurniawan & Wuri (2017) explained that the PBL model is divided into 3 stages, namely: problem design, describing and examining the problem; and simplifying, assessing and presenting.

The definition of direct learning model explained by Arend (Shoimin, 2014: 63) is a learning model specifically designed to support the learning process of students related to declarative knowledge and well-structured procedural knowledge that can be taught with a step-by-step pattern of activities. Fauzi and Metroyadi (2020) explain that the direct instruction model provides a disciplined structure and can lead to meaningful and systematic learning experiences. Meanwhile, Riduan and Rosmi (2024) explain that direct instruction is learning that emphasizes mastery of concepts or changes in behavior by prioritizing a deductive approach. Based on the description above, researchers can conclude that the direct instruction model is a teaching and learning process that provides space for students to build concepts directly related to activities to understand material objects with groups or individually and guided directly by the teacher.

The direct instruction model has stages in learning. Joyce, D. (2009: 185) explains that the stages of direct instruction learning consist of five stages of activity, namely orientation, the phase of delivering objectives; presentation, the demonstration phase;

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structured practice, the phase of guided practice; practice under guidance, the phase of checking students' understanding and providing feedback; and independent practice, the phase of independent practice.

Based on the description above, the purpose of this study is to compare the effectiveness between PBL and direct instruction models in instilling and developing critical thinking skills. So the title of this research is comparison of problem-based learning model with direct instruction in mathematics learning towards the development of critical thinking skills.

RESEARCH METHODS

The type of research is quantitative with the research design is Pretest-Posttest Control Group Design, where all groups are given a pretest before being given treatment / treatment and then observed the results. This experimental research is to investigate the effect of two independent variables simultaneously, namely the Problem Based Learning model and the Direct Instruction model on one dependent variable, namely critical thinking skills. The study population was all fourth grade students in Wonogiri sub-district, Central Java. The sampling technique used was cluster randam sampling.

Data collection techniques using tests. The incoming data were tested for prerequisites, including tests: normality, homogeneity, analysis of variance (Anava) two-way with unequal cells, using the formula:

$$X_{ijk} = \mu + \alpha_i + \beta_i + (\alpha\beta)_{ij} + \varepsilon_{ijk} \qquad \text{(Budiyono, 2016:229)}$$

and further test of two-way analysis of variance, using the Scheffe method, which is formulated:

$$F_{i;j} = \frac{(\overline{X_i} - \overline{X_j})^2}{RKG\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} \qquad \text{(Budiyono, 2016: 215)}$$

Notes:

$F_{i;j}$ = the value of F_{obs} on the comparison of the i-th row and the j-th row

$\overline{X_i}$ = mean at row i

$\overline{X_j}$ = mean of row j

RKG = mean square error obtained from the calculation of analysis of variance

n_i = i-th sample size

n_j = j-th sample size

RESULTS AND DISCUSSION

The sample test results in the experimental and control groups in this study were grouped into three criteria, based on the number of students. The results of grouping based on criteria, namely: High (group-1), Medium Criteria (group-2), and Low criteria (group-3). Pre-Test results are compiled in table 1.

Tabel 1. Descriptive Statistics

	N	Range	Min	Max	Mean	SD
PreTest_Kel1. Control	39	30	50	80	61.92	9.077
PreTest_kel2.Control	47	25	50	75	59.04	7.043
PreTest_kel3.Control	17	20	50	70	58.53	6.316
PreTest_kel1.Experiment	41	30	50	80	61.71	8.186
PreTest_kel2.Experiment	42	25	50	75	58.93	7.452
PreTest_kel3.Experiment	21	20	50	70	58.33	6.583
Valid N (listwise)	17					

Based on the table above, the mean and standard deviation results of control groups 1 to 3 are respectively: 61.92 and 9.08; 59.04 and 7.04; and 58.53 and 6.34. The experimental groups for groups 1 to 3, respectively are: 61.71 and 8.19; 58.93 and 7.45; and 58.33 and 6.58.

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The Post-Test results for mean and standard deviation are organized in table 2, as follows:

Table 2. Descriptive Statistics

	N	Range	Min	Max	Mean	SD
PostTest_Kel1. Control	39	30	70	100	81.67	6.721
PostTest_kel2.Control	47	30	70	100	80.53	7.241
PostTest_kel3.Control	17	20	70	90	77.94	5.321
PostTest_kel1.Experiment	41	20	80	100	90.61	6.819
PostTest_kel2.Experiment	42	20	80	100	89.64	7.105
PostTest_kel3.Experiment	21	25	75	100	85.48	6.875
Valid N (listwise)	17					

Based on the table above, the mean and standard deviation of control groups 1 to 3 are respectively: 81.67 and 6.72; 80.53 and 7.24; and 77.94 and 5.32, respectively. While the experimental groups 1 to 3 are respectively: 90.61 and 6.82; 89.64 and 7.11; and 85.48 and 6.88, respectively. Based on the table above, there is an increase in the mean score in control groups 1 to 3, respectively: 19.75, 21.49, and 19.41. While the increase in the mean score in experimental groups 1 to 3 respectively: 28.90, 30.71, and 27.15.

Pre-Test and Post-Test results need to be tested for prerequisites to pay attention as parametric statistics and continue further statistical tests. The prerequisite test consists of: normality test, homogeneity test, and independent test. The normality test in decision making is for a significant level of 5%, if the calculated significant value (sig. count)> 0.05, it can be interpreted that the data comes from samples from a population with normal distribution. The results of data processing using SPSS are arranged in table 3 as follows:

Table 3. Tests of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	Df	Sig.
Experiment Pre-test	0,162	103	0,075
Experiment Post-test	0,166	103	0,064
Control Pre-test	0,153	103	0,072
Control Post-test	0,191	103	0,068

Based on table 3 above, the sig. value of the experimental and control groups is 0.075, 0.064, 0.072, and 0.068 respectively, which is greater than 0.05. So it can be concluded that the sample comes from a population with normal distribution.

The results of the Pre-Test homogeneity test with a significant level of 0.05, the decision-making procedure is sig. count> 0.05, then the data is homogeneously distributed. The Pre-Test result data is arranged in table 4 as follows:

Table 4. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Pre-Test Learning Outcomes	Based on Mean	0,096	1	205	0,756
	Based on Median	0,099	1	205	0,753
	Based on Median and with adjusted df	0,099	1	204,994	0,753
	Based on trimmed mean	0,077	1	205	0,782

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Post-Test result data is organized in table 5, as follows:

Table 5. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Post-Test Learning Outcomes	Based on Mean	0,931	1	205	0,336
	Based on Median	1,084	1	205	0,299
	Based on Median and with adjusted df	1,084	1	204,381	0,299
	Based on trimmed mean	1,284	1	205	0,258

Based on tables 4 and 5 obtained Based on Mean each sig. count Pre-Test (0.756) > 0.05 and sig.count Post-Test (0.336) > 0.05, so it is concluded that the sample data has a Homogeneous distribution.

The results of the homogeneity test of homogeneously distributed sample data, then proceed with the balance test or t-test. The decision-making procedure with a significant level of 0.05 is sig. count> 0.05, so it is interpreted that the experimental group and the control group have the same or balanced average. Pre-Test learning outcomes data are organized in table 6 as follows:

Table 6. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Pre-Test	Equal variances assumed	0,096	0,756	205	0,893	0,145	1,078	-1,980	2,270
	Equal variances not assumed			204,778	0,893	0,145	1,078	-1,981	2,270

Based on table 6 above, it is found that sig. count (0.893) > 0.05, so it can be interpreted that the two groups have the same or balanced mean.

To see the effect of two learning models, hypothesis testing was carried out using analysis of variance (Anava) two-way unequal cells. Analysis of variance is carried out with the following procedure:

H_{0B} : $\alpha_i = 0$ for each $i = 1, 2, 3$; Project Based Learning (PBL) and Direct learning models in mathematics learning have no effect on the development of critical thinking skills.

H_{1B} : there is at least $\alpha_i \neq 0$ for each $i = 1, 2, 3$; Project Based Learning (PBL) and Direct learning models in mathematics learning have an effect on the development of critical thinking skills.

The significance level α=0.05, the critical area is $F_{count} > F_{table}$ (0.05, 2, 201).

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The computational results obtained that F_{count} (5.36) > F_{table} (3.91), so it is concluded that HOB is rejected or concluded that the Project Based Learning (PBL) learning model and direct learning model in mathematics learning affect the development of critical thinking skills.

Testing the demonstration learning model with direct learning to compare its effectiveness in achieving critical thinking development using the Scheffe method, the data is arranged in table 7, as follows:

Table 7. Mean Post-Test Results

Learning Model	Average Learning Outcome			Marginal
	High	Medium	Low	Average
PBL Model	90,61	89,64	85,48	88,58
Direct Instruction	81,67	80,53	77,94	80,05
Marginal Average	86,14	85,09	81,71	

The follow-up stage of Anava is to determine the effectiveness of the two procedural learning models in achieving the development of critical thinking skills. The data is organized in table 8, as follows:

Table 8. Summary of Multiple Comparisons between Row Cells

H_0	F_{count}	(pq-1) Ft_{able}	P
$\mu_{ij} = \mu_{ik}$	6396.61	6.08	Tolak H_0
$\mu_{ij} = \mu_{ik}$	6890.54	6.08	Tolak H_0
$\mu_{ij} = \mu_{ik}$	3223.56	6.08	Tolak H_0

The basis for decision is H_O: accepted if $\mu_{ij} = \mu_{ik}$; both learning models have the same effectiveness in developing critical thinking skills; H_1: accepted if $\mu_{ij} \neq \mu_{ik}$: both models have different effectiveness in developing critical thinking skills. At a significance level of 5%, the results of the calculation can be interpreted that: 1) PBL learning model is more effective than direct learning model for High criteria group with F count (6396.61) > F table (6.08); PBL learning model is more effective than direct learning model for Medium criteria group with F count (6890.54) > F table (6.08); and PBL learning model is more effective than direct learning model for Low criteria group with F count (3223.56) > F table (6.08). The conclusion of Anava further test is that PBL learning model is more effective than direct learning model in mathematics learning in developing critical thinking skills because F count for all criteria is greater than F table (6.08).

DISCUSSION

The results of hypothesis testing obtained that FHitung (5.36) is more than F table (3.91) which is interpreted that the Problem Based Learning (PBL) learning model using student worksheets (LKPD) and direct learning models using student worksheets (LKPD) have an influence in developing critical thinking skills in learning mathematics. This is because both learning models have learning stages in developing critical thinking skills, namely: the teacher has prepared the mathematics material by clarifying its structure, analyzing the material and preparing questions, making a summary formula of mathematical material that needs to be focused on, and preparing learning strategies. the learning stages are in accordance with the concept of Jacon and Sam (2008: 142) which explains that the stages of critical thinking learning include: 1) clarification, knowing the problem, such as understanding, identifying relevant data, and formulating the main problem, 2) Assessment, analyzing information, looking for important questions, and finding logical reasons in the process of solving problems, 3) inference, making conclusions based on relevant information, and 4) learning strategies, evaluating steps and results, and looking for alternative solutions.

The PBL learning model for all grouping criteria is better than the direct learning model. This is revealed from the stages of developing critical thinking skills, namely: brief explanation. The PBL learning model begins with a case or question that triggers students. While in the direct learning model, the initial explanation begins with the provision of objects or media whose explanation is initiated by the teacher. For example: identifying the name of objects, and demonstrating for concept achievement. In the aspect of decision making, both learning models also provide differences. PBL learning model, decision making after being able to complete the analysis based on structured questions. While the direct learning model, gives a decision after being given a question question and how to answer which directly leads to a mathematical concept or formula. The difference between the two learning models in developing critical thinking skills, the analysis is reviewed by the concept of critical thinking aspects from Ennis (2011: 4-18), namely: 1) Elementary Clarification, analyzing the problem by connecting to the concept of knowledge, so as to bring up several ideas for solving the problem; 2) Basic for Decisions, connecting various concepts that support the problem solving process and formulating problem solving; 3) Inference, synthesizing from several empirical experiences or experiences that can be measured by considering the concepts used; 4) Advanced Clarification, arguing the results of problem solving by providing definitions and concepts or theories that support problem solving; 5) Supposition and Integration, the ability to develop strategies to take action and to deduce the action.

The PBL learning model strategy is better than the direct learning model tested from the results of the marginal mean in learning mathematics. This is revealed from the marginal mean of the PBL model (88.58) higher than the marginal mean of direct learning (80.05). While the effectiveness is shown by the results of the Anava follow-up test, where at the 5% significance level, it is found that: the PBL learning model is more effective than the direct learning model for the High criteria group with F count (6396.61) > F table (6.08); Medium criteria group with F count (6890.54) > F table (6.08); and Low criteria group with F count (3223.56) > F table (6.08). This is because the PBL Learning model provides learning by applying strategies to connect mathematical material with the environment known to students and provide structured questions. This is in accordance with the concept of Widiasworo (2018: 149) which explains that the problem-based learning model is a teaching and learning process that presents contextual problems so that students are stimulated to learn. This effectiveness is also in accordance with the results of research from Nafiah, Y. N. (2014) which found that the application of the PBL model in learning PC repair and reset material can improve students' critical thinking skills in learning, namely by 24.2%. The results of research from Wulandari, O., Taufina, T. (2021) which concluded that a model that is widely adopted to support the learning centered learning model and emphasizes student involvement in the learning process actively as in the integrated thematic learning process is the Problem Based Learning (PBL) model.

CONCLUSION

The effectiveness of the Problem Based Learning model is better than the Direct Instruction model in developing critical thinking, due to the brief explanation stage. The PBL learning model begins with a case or question that triggers students. While in the direct learning model, the initial explanation begins with the provision of objects or media whose explanation is initiated by the teacher. In the decision-making aspect, the two learning models also provide differences. PBL learning model, decision making after being able to complete the analysis based on structured questions. While the direct learning model, gives a decision after being given a question question and how to answer which directly leads to a mathematical concept or formula.

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