The Effect of Problem-Based Learning Models on Mathematical Problem Solving Skills in Primary Schools

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Abstract - Problem solving is one of the important skills in learning mathematics in primary schools, that need to be improved. This study is aimed to improve mathematical problem solving skills using the problem-based learning (PBL) model. This research used quasi experimental design. The samples were 70 students who were divided into 35 students as the experimental group and 35 students as the control group. Problem-based learning is applied in primary schools at the semester two of 2019/2020 school year. Data analysis on mathematical problem solving skills used ANOVA at a significant level of 0.05. the results of research on mathematical problem solving skills showed that the experimental group had a better score than the control group. Therefore, it can be concluded that problem-based learning model is effectively applied to improve mathematical problem solving skills in primary school.

Keywords: Problem-Based Learning, Problem Solving, Mathematics at primary School

Introduction

Problem solving is an important skill in learning mathematics that should be mastered by students in the current era. The term “problem” in problem solving can be interpreted that the problem is a difficulty whose solution has not been found yet (Posamentier & Krulik, 2009). Using problem solving especially in mathematics education is the right approach to solve mathematical problems (Runtukahu & Kandou, 2014). Problem solving is an important skill which consists of some activities such as analyzing, interpreting, reasoning, and evaluating and reflecting the problem itself (Anderson, 2009). Similarly, Kilpatrick, Swafford, & Findell (2001) argue that problem solving provides important context for students to learn numbers and other mathematical terms. It can be said that problem solving skills are improved when students have the opportunity to solve the problem themselves and to see the problem being solved. In fact, NCTM (2000) suggests that teachers should develop students' mathematical problem solving earlier. Furthermore, Rudyanto, Gufron, & Hartono (2019) reveal the need for innovation in mathematics learning conducted by the teacher so that students master mathematical skill that can later be used in solving students' daily problems. Thus, mathematics problem solving skills must be possessed by children from primary school level.

Previous research states that overall problem solving skills tend to decrease every year (Werner et al., 2012). This agrees with Lee, Yeo, and Hong (2014) explaining that primary school students experience difficulties in solving mathematical problems because they need knowledge, methods, and discipline to learn (Liu et al., 2017). Furthermore (Johnson et al., 2011; Yu et al., 2014) states that most

students only learn to solve structured problems related to newly learned material. In fact, these assignments are only used as student exercises in evaluating learning (Ozcan, 2015). Therefore, it is very important to train students in solving non-routine problems using appropriate learning methods or techniques so that students are able to work on problems both at school and outside of school.

These problems need to be solved by implementing appropriate methods to guide students to think at a higher level and solve mathematical problems (Darling-Hammond et al., 2019). Several learning models have been applied to improve mathematical problem solving skills. However, the problem-based learning (PBL) model is seen as the most effective learning model in improving mathematical problem solving skills (Li & Tsai, 2017). In this study, PBL as learning model is used to solve problem that have been experienced by students before in order to obtain new knowledge. There are five steps in learning using the PBL such as; problem analysis, setting learning objectives, gathering information, summarizing and reflecting (Lin et al., 2010).

Teacher in PBL is only a facilitator *(student centered*) where relevant problems are introduced early in the instruction cycle and are used to provide context and motivation in learning (Michael, 2004). Furthermore (Tan, 2003; Wee & Kek, 2002: 12) states that PBL is learning approach by making confrontation to students with some practical problems that have a context with the real world. So it can be stated that the Problem Based Learning (PBL) model is a learning model in which students are actively involved in solving problems in students 'daily lives, so that this learning model can improve mathematical problem solving skills and students' learning motivation increases.

Previous research also revealed that primary school students really enjoyed PBL as a result of their curiosity (Copley, 1999). As a model of learning mathematics, PBL provides opportunities for students to present their assignments as well as questions and answers with their peers in the learning process in class (Erickson, 1999; Van de Walle, 2001). In addition, PBL is able to make learning in schools more meaningful and make students able to develop skills in solving mathematical problems (Kammanee, 2008).

Many researchers have implemented PBL learning models to improve their mathematical problem solving skills, but the findings are varied. Previous studies have shown that PBL is effective in increasing environmental attitudes, independent learning, and science process skills compared to traditional learning (Sungur & Tekkaya, 2006; Wilder, 2014). In addition, mathematics learning shows that students taught with PBL learning models have more effective results in understanding long-term concepts and knowledge than students who are taught with teacher-centered learning (Li & Tsai, 2017; Wirkala & Kuhn, 2011). But, the application of PBL in improving problem solving skills in primary schools is still rarely explored. Thus, in the current research, we focus on exploring the effects of PBL to foster students' problem solving skills in mathematics in elementary school. Therefore, this study is aimed to determine the effect of PBL to improve mathematical problem solving skills in primary schools.

This experimental research used Quasi Experimental research design. The subjects of the study were two classes from two parallel school consisting as one experimental group class and one control group class selected using random sampling technique. This research was conducted in October of academic year 2019/2020.

Tabel 1. Pretest and Posttest Control Group Design

Groups	**Pre-test**	**Treatments**	**Post-test**
Experimental	MPSS	Problem-based learning	MPSS
Control	MPSS	Conventional teaching	MPSS

Research Sample

The samples were 70 students of 5th grade (11-12 years old) at SDN Ganungkidul, Indonesia. All students were divided into experimental groups (n = 35) and controls (n = 35) selected by random sampling. Students in the experimental group were taught using problem-based learning (PBL) model and the control group using conventional learning model. All students had equal abilities and livedin cities with moderate economic levels. All students were taught by one teacher who has more than 5 years of learning experience and certified Education qualification. Furthermore, the teacher is given direction to apply a different learning model, namely learning with PBL model and learning with conventional learning models.

Research Instruments

Mathematical problem solving skills consisted of 4 sub-scales adapted from Polya (1973), such as understanding problems, making plans, solving problems according to plan, and making conclusion. In detail, the scoring rubric for problem-solving skills was presented in Table 2.

Table 2. Problem Solving Skills Rubric

Sub-scales	**score**	**Scoring indicators**
understanding problems	2	Students write what is known and what is asked clearly from the given problem.
	1	students write what is known and what is asked but not related to the problem given.
	0	students do not write down anything from the problem
making plans	2	Students write the completion of plan and use all the information that has been collected.
	1	Students write a plan for completion but not coherent
	0	Students do not write plans to solve problems
solving problems according to plan	4	Students Solve problems according to plans that have been made correctly, there are no procedural errors, and no calculation errors
	3	Students Solve problems according to plans that have been made, there was no procedural error, but calculation errors occurred
	2	Students Solve problems according to plans that have been made, but there are procedural errors and calculation errors.
	1	Students Solve problems according to plans that have been made, but there are procedural errors and calculation errors
	0	Students do not solve problems according to plans that have been made
making conclusion	2	Students make conclusions in accordance with the questions and results
	1	Students make conclusion but do not match the questions and results
	0	Students do not make conclusion

The instrument of mathematical problem solving skills consisted of 6 items in the form of description. All questions had been adjusted to basic competencies and indicators in accordance with the curriculum in primary schools (Ministry of Education., 2013). Furthermore, the instrument was validated by two mathematics education experts. The validation related to: (1) the suitability of the questions with the indicators, (2) the level of difficulty of the questions, (3) the use of language, (4) the truth of the concept. After being validated by expert judgment, it was empirically validated to 30 students at SDN Kedungdowo, Indonesia. Based on the results of the test, 5 questions were classified

as valid and 1 question was classified as invalid (table 3). After analysis, the reliability coefficient of the test was 0.674.

Table 3. Validity of Item Problem Problem solving skills

Items	$r_{observed}$	r_{table}5% (*n*=30)	*p*	Criteria
Question 1	0,710	0,361	0,000	Valid
Question 2	0,100	0,361	0,599	Invalid
Question 3	0,582	0,361	0,001	Valid
Question 4	0,417	0,361	0,022	Valid
Question 5	0,733	0,361	0,000	Valid
Question 6	0,638	0,361	0,000	Valid

Results and Discussion

Data analysis in this study used the One-way ANOVA statistical test to determine the average pre-test between the experimental group and the contral group in mathematics problem solving skills in elementary school. The results are shown in Table 4.

Tabel 4. One-way ANOVA results for pre-test mean scores

Dependent Variables	Groups	*M*	*SD*	*df*	*F*	*p*
Problem Solving	Experimental	57.30	10.19	1	2.925	.092

The table 4 shows that there is no difference in the pre-test scores between the control and experimental group in mathematical problem solving skills ($p > 0.05$). Thus, it can be stated that both the experimental group and the contral group have the same ability in mathematical problem solving skills.

Furthermore, ANOVA statistical test is used to determine the effect of PBL learning models. The results of the analysis of the effect of the PBL model on mathematical problem solving skills are presented in Table 5.

Tabel 5. One-way ANOVA results for post-test mean scores

Dependent Variables	Groups	*M*	*SD*	*df*	*F*	*p*
Problem solving	Experimental	76.73	11.01	1	27.431	.000

Based on table 5 above shows that students in the experimental group (M = 76.73; SD = 11.01) had higher mean score than control group (M = 62.23; SD = 12.01). Thus, it can be stated that there is significant difference in learning using PBL models [$p < 0.05$]. The findings in this study indicate that learning process using different learning models affects the average post-test scores between the experimental group and the control group students.

This study has tested the effect of problem-based learning (PBL) model on mathematical problem solving skills compared to conventional learning. The ANOVA results show that students who are taught with PBL model higher than students who are taught using conventional learning models. The mathematical problem-solving skills in primary school students may increase because teachers continue to innovate in creating active, creative, and fun learning activity through group discussions. In student-centered learning, students are always required to be active and given the opportunity to ask questions in accordance with the material relating to students' daily lives. Thus, it can be stated that learning can

improve students' mathematical problem solving skills. The results of this study are in line with research conducted by (Cook & Moyle, 2002; Morales-Mann & Kaitell, 2001), where PBL models produce significant and clear benefits for students that are able to improve mathematical problem solving skills.

The students' pre-test and post-test results in experimental and control group showed a change in mathematical problem solving skills. But the changes occurred significantly in the experimental group. In this case, the experimental group gave a better effect after using PBL model. The post-test scores were high because the teacher always facilitates students by linking learning to the context of students' daily lives (Johnson, 2011). In this case, mathematical problem solving skills will develop well when learning is associated with students' real situations (Wright, 2001). This finding is in line with Pedersen and Liu (2002) which states that students taught using PBL succeed in developing problem solving skills relates in their live. Furthermore, the study results reported by Argaw et al. (2017) also showed that PBL significantly promoted students' mathematical problem solving skills. Thus, PBL learning models need to be applied in solving mathematical problems both in the classroom and at home.

Conclusion

The results of this study shows that the average score of students' mathematical problem solving skills in the experimental group increases after using the problem-based learning (PBL) model compared to students in the control group. The use of problem-based learning (PBL) help students to solve mathematical problems. Thus, the results of this study indicate that problem-based learning (PBL) is effective for improving mathematical problem solving skills in primary schools. Furthermore, students are more active and learning becomes more meaningful because teachers are able relate the problem with real lives through group discussions.

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