

*Full Length Research Paper*

# Improving primary students' mathematical literacy through problem based learning and direct instruction

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This research was done on primary school students who are able to understand mathematical concepts, but unable to apply them in solving real life problems. Therefore, this study aims to improve primary school students' mathematical literacy through problem-based learning and direct instruction. In addition, the research was conducted to determine whether there are differences in the increase in literacy mathematical among students who received problem-based learning and direct instruction in primary schools located in urban areas, transition, and villages, as well as whether there is an interaction effect between the model of learning by location category of the school toward mathematical literacy skills of primary school students. The study was conducted in the academic year 2015 to 2016 in the fifth grade public primary schools in Bandung with three categories of school location (rural, city and county transition). During the research, one experimental group was treated by problem based learning, while the second experimental group was treated by direct instruction. The research approach used was a quantitative approach with quasi experimental method nonequivalent groups design pretest-posttests. The results showed that: there was a significant difference between the increase in mathematical literacy of students who received a model of problem-based learning (PBL) and direct instruction (DI) model; PBL model was more effective in improving students' mathematical literacy model than the DI; There were no significant differences regarding an increase in students' mathematical literacy by category location of the school; there is no interaction effect between the model of learning by school location factors to the increase in students' mathematical literacy.

**Key words:** Mathematical literacy, problem based learning, direct instruction, mathematics education, primary school.

## INTRODUCTION

Education is one of the core needs for humans being, because through education people can develop their natural potential given by Allah which are Al'jasad (physical), Al-Aql (intellect) and Ar-Ruh (spiritual) for the

maturity of human beings.

Therefore, education is expected to develop a wide range of potential of the students. Education is also an important factor for the development of a country,

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because education is expected to create individuals with high potential and quality Human Resources (HR) in the advancement of the nation. In Indonesia, education is required for all citizens: nine years' compulsory basic education for primary and junior high school. Therefore, basic education is important when taken for all citizens, because basic education is a process for developing a basic human capacity optimally in the intellectual aspects, social and personal. In addition, basic education is also the beginning of the acquisition of the next level of education.

The purpose of primary education is to establish the basic personality of student as whole Indonesian persons based on the level of development; development of basic understanding of science and technology, a foundation for learning in higher education and public life.

Basic education, beginning with primary school (SD), is a compulsory requirement for higher education. Primary school education is very important to equip students to prepare themselves in taking life as well as to develop its potential. One concept that is learned in primary school is math. Effective mathematics teaching requires an understanding of what students know and need to learn and then challenging and supporting them to learn it well (NCTM, 2000).

Therefore, all students learn math concepts, almost entirely dependent on the experience of teachers teaching in the classroom every day. So to achieve quality mathematics education in primary school, the teacher must:

1. Deeply understand math concepts taught in primary school.
2. Understand the characteristics of primary school students' learning, and
3. Choose strategies and mathematical tasks in accordance with the characteristics of primary school age children.

The latest curriculum in Indonesia on education and learning of mathematics in schools or other learning namely is 2013 Curriculum. 2013 Curriculum Development is a further step for developing Competency Based Curriculum which was initiated in 2004 as well as KTSP curriculum (2006). This includes competency attitudes, knowledge, and skills in an integrated manner. The rationale for creating 2013 curriculum development is due to a variety of external challenges involved in the deepening and expansion of the material. In that regard, the 2013 curriculum development is a step towards strengthening the material. This was carried out by the Indonesian Government to re-evaluate the scope of the material contained in the curriculum. This was done by eliminating materials that are less essential or less relevant to students, maintaining the material according to the needs of learners, and adding material considered

important for international comparison.

Based on government programs on 2013 curriculum development, the expected competencies of learners in various domains (cognitive, affective and psychomotor), competencies per area of study, as well as others including mathematical literacy can thrive well. Mathematical literacy (mathematical literacy) is about usability or mathematical functions that have been learned by the students in the school to everyday life in order to compete in a globalized world. In the PISA (OECD, 2013), mathematical literacy was often disputed in junior high school and high school students.

Mahdiyansyah and Rahmawati (2014) study showed that the mathematical literacy of students of secondary education is still low, even though the international test design used has been adapted to the context of Indonesia. Based on the PISA (OECD, 2013) and Mahdiyansyah and Rahmawati (2014)'s study discuss the lack of mathematical literacy in junior high school and senior high school is also experienced by primary school students; therefore mathematical literacy must also be developed in primary school students as the basis for the acquisition of basic mathematical concepts. Mathematical literacy problems high school students did not rule out the impact of mathematical literacy problems and learning primary students. Mathematical literacy problems of primary school students have looked at some of the students were only able to understand a mathematical concept, but some students are still less capable of connecting between mathematical concepts and apply mathematics in reducing the problems found in everyday life. It is also marked on the presence of some students who are not able to give right answer the case stories, especially about non-routine related to mathematical concepts that are discussed in primary school.

UNDP (2000) and the International Evaluation of Education Achievement (2000) reported the low quality of Indonesian students' ability to compete in the era of globalization, particularly in mathematics and science (Dewanto and Sumarno, 2013). The latest results from the Programme for International Student Assessment (PISA) in 2012 showed further decline in student achievement in Indonesia where the majority of students Indonesia has not reached level 2 (75%) and 42% of students have not even reached its lowest level (level 1), whereas in PISA mathematics years 2009, almost all Indonesian students reached level 3 and only 0.1% of Indonesian students were able to reach level 5 and 6. From the results of the combined tests of mathematics, science, and reading, in PISA 2012 Indonesia was ranked 64 out of 65 participating countries (OECD, 2013).

Similarly, in the case of iterations, the study results Progress in International Reading and Literacy Study (PIRLS) intended for class V, SD also showed that over 95% of Indonesian learners in grade V were at the middle

level, while more than 50% of Taiwan students got to the highest level (Kemendikbud, 2014). Mathematical literacy is important because it can facilitate students in solving real life problems related to mathematical concepts (Garfunkel, 2013).

Important capabilities in mathematical literacy are the ability to propose, formulate and resolve within or outside the mathematical problems in a variety of contexts. Such capabilities include all things in teaching mathematical concepts are given from the beginning. However, it would be much better if the students first introduced the concept of math through problem poser, problem solver, or both (Johar, 2012). Furthermore, Suyitno (2013) explains the mathematical literacy as follows:

1. Mathematical literacy defined as the ability of a person (in this case, students) to formulate, implement, and interpret mathematics in various contexts, including the ability to perform reasoning mathematically and using the concepts, procedures, and facts to describe, explain, or predict phenomena / events.

2. Problems that includes literacy mathematics, are the problems with certain characteristics such as:

- a. Non-routine
- b. Solving the problem
- c. Require higher order thinking (HOTS, higher order thinking skills) of students
- d. The solution requires two or more formulas
- e. Contains interpretations mathematics utilization in various contexts, and
- f. Be able to cultivate students' creative ideas to explain the reason why algorithm is chosen.

Problem-based learning is a learning that utilizes problems, questions, or puzzle (puzzle) as a trigger (trigger) for the students' learning process (CIDR, 2004). Padmavathy and Mareesh (2013) study revealed the effect of problem based learning in teaching mathematics to enhance students' understanding, and the ability to use the concept in real life.

Understanding and ability to use the concept in real life is a part of mathematical literacy competence. In addition, Tan (2003) explained that through problem-based learning, students are motivated to learn is high, develop higher level thinking skills, teamwork and communication skills (Tan, 2003). Based on the opinions and research on these experts, it is expected that through the implementation of a model problem based learning can improve students' mathematical literacy in primary school.

Direct instruction is a teaching model that consists of the teacher's explanation of the concept or skill of the students followed by asking the students to test their understanding by doing practice under the guidance of teachers (practice controlled), and encourage them to

continue to practice under the guidance of a teacher (Joyce et al., 2011). Din (2000) conducted a study on models of direct instruction which indicates that after guiding, the students made significant gains in their basic math skills. So applying the direct instruction model can improve students' mathematical literacy in primary schools

## METHODOLOGY

The research approach used was a quantitative approach. This is because this study tries to control how groups of research subjects are taught and then measures how the teaching affects each group. The method used in this research was quasi experiment because the research was carried out with the intention to learn something by changing conditions and observing their effects on other things.

Quasi experimental study conducted is to form groups of non-equivalent pretest-post- test design based on the idea of Fraenkel and Wallen (2007). The population of this research was all fifth grade students of primary schools in the county and cities of Bandung. Research samples of six primary school consisting of four primary schools from Bandung District represent the rural (SDN Cipaku 02 and 03) and transition areas (SDN Cinunuk 02 and 07), and two primary schools in the Municipality of Bandung represent urban areas (SDN Kebon Gedang 01 and 09).

The research instrument used was a test sheet evaluation of students' mathematical literacy in geometry for fifth grade primary school. The evaluation tests of students' mathematical literacy were conducted in order to understand and identify the mathematical literacy of students regarding instructional materials was learnt, where the implementation of the evaluation study aim to measure students' mathematical literacy in the subject matter being discussed. Instrument development was done by testing the validity criterion, the empirical validity and reliability testing The validity test was done using the formula of Pearson product moment correlation coefficient; the validity of the instruments was 0.673; R critical, 0.349. Meanwhile, empirical validity of the test results showed that the 15 questions that were tested had a valid criterion consisting of six questions about the nine categories of good and sufficient criteria. In addition, the reliability of the calculation results using Alpha-Cronbach formula was 0.785, suggesting that the results of the test instrument have high reliability.

The data analysis determines the increase of primary school students' mathematical literacy through problem-based learning and direct instruction. Data analysis technique used in this study was a statistical technique inferential parameters, where the technique was carried out using t-test, Mann-Whitney U test one-way ANOVA, test two-way ANOVA and post hoc test Kruskal-Wallis, with a significance level of 0.05. The quasi-experimental design was implemented as follows: Firstly, it involves the planning and preparation of the research; it begins with the definition of the research problems, a search for reference materials, designing of the research hypothesis, the study design, selection of a sample of a given population according to the study design, making lesson plan (RPP) of problem based learning and direct instruction models, as well as making the instruments used for the research. Secondly, conducting of the research: the research was done by placing the sample in experimental group 1 and experimental group 2, giving pretest to each group, based on the dependent variable. Experimental group 1 was taught with by using problem-based learning and experimental group 2 was taught by using direct instruction; and each group was given a posttest based on the dependent variable. Thirdly, data collection and analysis of data

**Table 1.** Significance test results students' mathematical literacy from both groups.

Model	N	Mean	Mean difference	Mann-Whitney U	Wilcoxon W	Z	Sig.	Result
PBL	115	0.73	0.19	605.000	6170.000	-11.532	0.000	H <sub>0</sub> is rejected
DI	105	0.54						

**Table 2.** Significance difference test results students' mathematical literacy among students improvement between student with PBL and DI treatment in the schools located in the village.

Model	N	Mean	Mean difference	t	df	Sig.	Result
PBL	42	0.73	0.19	12.927	84	0.000	H <sub>0</sub> is rejected
DI	44	0.54					

was done. Fourthly, research report was taken.

## RESULT

Results of the hypothesis testing begin with equality test data with an increase of students' mathematical literacy based learning model presented in Table 1.

Table 1 shows that the probability value (sig.) is less than  $\alpha = 0.05$ , so H<sub>0</sub> is rejected. Thus, there are significant differences improvement of students' mathematical literacy who received the model PBL and students who received DI models. In addition, it is known that students who get significantly PBL models earned an average improvement of students' mathematical literacy was greater than students who received DI models with an average difference of 0.19 increase.

Further testing was the significance testing of the differences in the increase of primary school students' mathematical literacy in three school locations. Results of the significant difference in the students' mathematical literacy improvement in relation to schools located in the village are presented in Table 4.

In Table 2, it can be seen that the probability value (sig.) is less than 0.05, which means that H<sub>0</sub> is rejected. Thus, there are significant differences in the mathematical literacy of those students who received the PBL and DI models in schools located in the village; those who received the PBL model significantly obtain an average increase in mathematical literacy more than those that received DI model in primary schools located in the village. Results of the tests of significance difference in the increase of students' mathematical literacy in relation to schools located in the cities using t-test are presented in Table 3.

In Table 3, it can be seen that the probability value (sig.) is less than 0.05, which means that H<sub>0</sub> is rejected.

Thus, the increase in students' mathematical literacy who received the PBL and DI models in schools located in cities have significant differences; those students who received the PBL model significantly obtain an average increase in literacy mathematical greater than those students who received DI models in primary schools located in cities.

Results of the tests of significance difference in the students' mathematical literacy improvement in relation to schools located in transition area using t-test are presented in Table 4. In Table 4, it can be seen that the probability value (sig.) is less than 0.05, which means that H<sub>0</sub> is rejected. Thus, the increase of student's mathematical literacy who get the PBL model and DI in schools located in the transition region have significant differences, as well as students who treated with PBL model significantly obtain the average increase in literacy mathematical greater than that received models DI in primary schools located in transition area. To see the influence of the learning models and location of the school on the increase in students' mathematical literacy, t two-way ANOVA test was done. The test results are summarized in Table 5.

According to Table 5, the teaching model obtained sig. <0.05, which indicates H<sub>0</sub> was rejected. There was a significant difference in students' mathematical literacy improvement due to differences in teaching model given. As for the category of the location of the school and the interaction between the learning model with the location of the school obtained sig. > 0.05. H<sub>0</sub> was accepted, and there was no significant difference due to the increase in students' mathematical literacy based school location factors or as a result of interaction between the learning model with location of the school. Thus, there was no interaction effect between the teaching model with school location factors to the increase in students' mathematical literacy.

**Table 3.** Significance difference test results students' mathematical literacy among students improvement between student with PBL and DI treatment in the school located in the city.

Model	N	Mean	Mean Difference	t	df	Sig.	Result
PBL	22	0.76	0.22	9.227	48	0.000	H <sub>0</sub> is rejected
DI	28	0.54					

**Table 4.** Significance difference test results students' mathematical literacy among students improvement between student with PBL and DI treatment in the school located in the transition area.

Model	N	Mean	Mean difference	t	df	Sig.	Result
PBL	51	0.70	0.17	9.793	82	0.000	H <sub>0</sub> is rejected
DI	33	0.53					

**Table 5.** Results of Interaction test between teaching model and school area toward the increase of students' mathematical literacy.

Source	Type III sum of squares	Df	Mean square	F	Sig.	Result
School located	0.034	2	0.017	2.961	0.054	H <sub>0</sub> is accepted
Model	1.919	1	1.919	333.039	0.000	H <sub>0</sub> is rejected
Interaction	0.023	2	0.012	2,021	0.135	H <sub>0</sub> is accepted
Error	1.233	214	0.006	-	-	-
Total	92.314	220	-	-	-	-

## DISCUSSION

From the research results, problem based learning model proved to be effective in improving students' mathematical literacy. The results of the data analysis showed a significant difference between mathematical literacy scores of experimental group 1 and experimental group 2, when direct instruction model was used. This is because in essence, mathematical literacy is the ability to help students in solving real-life problems related to mathematical concepts (Garfunkel, 2013). This is in line with the opinion of Johar (2012), who revealed that mathematical literacy capability is the ability to propose, formulate and resolve problems within or outside the mathematics in a variety of areas and contexts. Such capabilities include everything, ranging from pure mathematics to cases where there are no mathematical structures; it has been given from the beginning but is first introduced through problem poser, problem solver, or both.

Based on the opinion of Garfunkel (2013) and Johar (2012), mathematical literacy is the ability of students to solve problems. This is particularly appropriate for developing students' mathematical literacy using problem-based learning model, because it is an effective way to solve problem and it enhances the skills used in

solving problems (Ozcan and Balim, 2013; Temel, 2014). Furthermore, Bilgin et al (2009) explain that the purpose of problem based learning is to help students to think, solve problems and to improve their thinking skills by building a real situation or relating concepts to be learned.

Students' mathematical literacy needs to be developed since they are in primary school. Mathematical literacy is very important for the realization of universal primary education as embodied in the Millennium Development Goals (MDGs). Therefore, mathematical literacy should be improved with the relevant teaching materials, laboratory mathematics and electronic libraries, to meet the expected program of universal primary education. If the mathematical literacy is well developed, enhanced and quite successful, it could lead to the acquisition of mathematical skills that can lead to the achievement of universal primary education (Adeyemi and Adaramola, 2014). As the mathematical literacy of students needs to be developed since they are in primary school, there is the need for a research to develop the mathematical literacy of primary school students. This was confirmed by the results of Afkhami et al. (2012) who found that students in primary school are more successful in mathematical literacy compared to junior high school and senior high school students. Mathematical literacy of

junior high school and senior high school students had no significant difference.

In primary school, students are already taught mathematical literacy through the process of mathematical problem solving in everyday life. Learning can be implemented through a problem-based learning. Problem-based learning is an education that emphasizes problem as the starting point of the learning process. These types of problems depend on the specific organization. Typically, the problem is based on real life; problems that have been selected and edited to meet the objectives and criteria of education (Graaff and Kolmos, 2003). Problem-based learning as a model of learning that develops problem-solving skills is very supportive toward the development of mathematical literacy, because basically one's capability in the development of mathematical literacy is the ability of solving real problems that often arise in the daily life of students. Besides the ability to problem-solving in everyday life, students with mathematical literacy have the following capabilities:

1. Basic mathematical knowledge and skills required of citizens in a modern and practical basic core of knowledge of mathematics.
2. A certain level of computational ability, logical reasoning, and understanding the concept of spatial (or at a beginner level, spatial imagination)
3. Interest in applying mathematics to understand numbers and symbols, and a basic understanding of mathematical concepts; and
4. Character traits that are important for learning mathematics (Tai et al., 2014).

Furthermore, in PISA 2012 (OECD, 2013), the seven components in the assessment of mathematical literacy are presented namely communication, mathematizing, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal and technical language and operations, as well as using mathematics tools.

Therefore, problem based learning is suitable to develop skills and competencies of primary school students' mathematical literacy, where students learn through problem-based learning, information about their skills after participating in problem based learning, problem solving, self-confidence, critical thinking, and teamwork. Apart from the acquisition of skills, problem based learning also encourages them to have in-depth understanding, improve their theoretical knowledge, and promote a deep approach to learning (Borhan, 2012).

The effectiveness of problem based learning in improving students' mathematical literacy also strengthens the results of the research conducted by Padmavathy and Mareesh (2013) which showed the effect of problem based learning in teaching and

understanding mathematics and the ability to use it in real life; where understanding and ability to use the concept in real life is a part of mathematical literacy competence. Implementation of the model of problem based learning is done through four stages: reviewing and presenting problems, developing strategies, implementing the strategy, and discussing and evaluating the results (Eggen and Kauchak, 2012).

In addition to implementing each stage of problem based learning presented by Eggen and Kauchak (2012), the problem based learning can also be implemented through fun method and in accordance with the characteristics of primary school age children, that is by singing and storytelling. This method is expected to develop problem based learning which attracted the attention of primary students so that students' mathematical literacy can thrive. This is in line with the opinion of Levenberg (2015) which states that integrating songs and stories in mathematics which is used as an important tool for the cultivation of mathematical literacy as well as one of the ways to overcome learning difficulties. Learning mathematics is important if environmental topics related to children are integrated. Mother Goose is one of the songs that can be used to carry out mathematical activities dealing with issues of series and their graphical presentation.

In social constructivism view, mathematics can be considered as a social construction. This refers to the traditional nature, in accepting the fact that human language, rules and agreements play a key role in developing and justifying mathematical truth. In accepting that mathematics is a social construction, it is implied that mathematics as objective knowledge which is the product of humans thinking. The application of mathematics has two reasons:

1. Mathematics is based on empirical natural language, and
2. Semi-empiricism mathematical meaning that is not so different from empirical science (Ernest, 2004).

One model of social constructivism view is the problem-based learning model. The theoretical basis of problem based learning is collaborativism, where collaborativism is a view which argues that students will develop knowledge by building reasoning of all the knowledge he/she already had and all acquired as a result of activity of interacting with other people. It also implies that the learning process moves from the facilitator of information transfer students to the knowledge construction process of social and individual nature. According constructivism, humans can only understand through self-construction (Lidinillah, 2008). Thus, the problem based learning model is very suitable to implement, develop and justify mathematical truth.

Zheng and Zhou (2011) also explained one of the

characteristics of problem based learning in which every complex question is decomposed into a series of fine coherent sub-questions following criteria carefully designed to maintain a balance between guiding students and inspiring them to think independently. Learning problem based learning allows students to solve complex questions in the context of progressive inductive. Therefore, mathematical literacy students can develop well through a series of complex questions to solve problems in everyday life. Students who obtain a model of learning by using problem-based learning in the learning process in this study is known to have higher literacy than students taught with direct instruction models. It is marked on the N-gain value where the difference between the students who got the problem based learning models and direct instruction model was equal to 0.17. In addition, the mathematical literacy enhancement significance test also showed that there are differences in mathematical literacy improvement of students who received problem based learning model and those who received direct instruction model.

The results of the study showed that students who learned with problem based learning model in the learning process had an increased literacy than those students who learned with direct instruction model. This is reinforced by the opinions of Etherington (2011), who revealed that the problem based learning deserves a more prominent place in science undergraduate primary education for teachers because the process empowers students and educators to direct the study, define and analyze problems and develop solutions. Limitations found in research are very acceptable, because there is no perfect thing. Certainly there will be weaknesses in different aspects. The limitations in this research are as follows:

1. Sampling was not done randomly (random), so it cannot fully control the variables that could affect the implementation of the experiment.
2. Lack of control variables, so characteristic in the treatment group could not be made equal to or equated.

Based on those limitations, the researchers recommend further research that would be much better by using mixed research methods. This will make the research findings more accurate, valid, reliable and trustworthy. Sampling should be done randomly in order to fully control the variables that could affect the demographics such as age, gender, social and economic background of the research subjects.

## CONCLUSION

In line with the formulation of the problem and research questions, the study came to the conclusion with respect

to the results of empirical studies on the experimental problem based learning to improve mathematical literacy of fifth grade students in primary school. Based on the research results obtained, the followings are concluded: First, there are differences in the increase of mathematical literacy of students taught with problem based learning and those students taught with direct instruction model in schools located in rural, urban and transition regions.

Secondly, the interaction between the learning model and location of school affected the increase in students' mathematical literacy. The interaction between the teaching model and location of school may not be sensitive to primary school students' mathematical literacy. Differences in the increase of students' mathematical literacy are only caused by different teaching models. By ignoring the factor, location of the school, the teaching model makes an impact on students' mathematical literacy.

Therefore, the interaction between the model problem based learning and direct instruction models affects the students' mathematical literacy, where the problem based learning model has a significant influence on the improvement of primary school students' mathematical literacy. So, whatever the location of the school, both in the village, town or transition areas has no effect on enhancing students' mathematical literacy. But rather an increase in students' mathematical literacy is influenced significantly by learning model (problem based learning and direct instruction models). Mathematical literacy of the students can increase by implementing learning model and the location of the school.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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