The effectiveness of PO2E2W learning model on natural science learning to improve problem solving skills of primary school students

S Pratiwi1*, B K Prahani2, S Suryanti3 and B Jatmiko4

1 Pascasarjana Pendidikan Dasar, Universitas Negeri Surabaya, Jl. Ketintang, Surabaya 60231, Indonesia
2 Pendidikan Guru Madrasah Ibtidaiyah, UIN Sunan Ampel Surabaya, Jl. A. Yani No.117, Surabaya 60237, Indonesia
3 Jurusan Pendidikan Guru Sekolah Dasar, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lakarsantri, Surabaya 60213, Indonesia
4 Jurusan Fisika, Universitas Negeri Surabaya, Jl. Ketintang, Surabaya 60231, Indonesia

*siskapratiwi01@gmail.com

Abstract. The PO2E2W learning model (problem oriented, observation, explanation, orientation, and write in science) is a self-regulated learning-oriented learning model that is designed to improve problem-solving skills. The purpose of this study is to analyse the effectiveness of PO2E2W learning model on natural science learning to change the problem-solving skills of primary school students. This research used one group pre-test and post-test design in fourth grade students of academic year 2017/2018. Students’ problem-solving skills were measured by using Problem-Solving Skills Assessment Sheet (PSSAS) and Student Response Questionnaire. The indicators of problem-solving skills include representing the problems, developing solutions, justifying proposed solutions, and evaluating the solutions. The data analysis technique used Paired test, n-gain, and Independent test. The results of the study prove that: (1) There is an increase in problem-solving skills of primary school students at $\alpha = 5\%$; (2) The average score of n-gain of the students’ problem-solving skill was in medium category; (3) There is no significant (consistent) difference on the natural science problem-solving skills in all groups, and (4) Students responded very positively. Therefore, the learning model of PO2E2W on natural science learning has proven to be effective to improve the problem-solving skill of primary school students.

1. Introduction

The qualified human beings should have 21st century skills that include scientific creativity, critical thinking, and scientific collaborative skills, have science literacy in solving problems that is caused by the impact of science and technology development [1-7]. In the 21st century, we are inseparable from the problem, so the problem-solving skills need to be trained to students from an early age, so that they can be accustomed and easily in solving problems that arise in their lives. Problem-solving skills are a person’s ability to involve cognitive processes to solve problems [3-4,8]. Problem-solving skills have an important role in students’ success in the future [3-4,8]. Therefore, primary school students as the
successor of the Indonesian nation must be trained to have problem-solving skills to be able to excel in the competition in the era of industry revolution 4.0. The indicators of problem solving skills in this study include problem representation, solution development, justification of proposed solutions, and evaluation of the solutions, based on the results of literature studies and preliminary study trials by researchers, these four indicators are still low and need to be improved by primary school students on natural science subjects.

The results of the PISA survey in 2015 showed that Indonesia's acquisition scores, especially in the field of science, are still below the minimum limit, so that Indonesia is ranked in 62 out of 72 countries that were participated in this activity [9]. The problem-solving skills of primary school students are still low due to the fact that teachers do not maximally train students to apply problem-solving skills [10]. This is reinforced by the results of preliminary study in class V of state primary school Kemayoran 1 (Madura, Indonesia) which shows that (1) only 20% of students are able to answer problem-solving skills, (2) students have difficulty in using problem-solving skills because they are not accustomed with that, and (3) the problem-solving exercises that are given by teachers are still routine or the problems that are presented are still in well-structure categories. This is reinforced by the results of the study [11-14] that most teachers still apply lecture methods which is cantered to the teacher in learning, the science process skills and problem-solving are not maximized in natural science learning. Therefore, an innovative learning model is needed to improve the problem-solving skills of primary school students.

One of the innovative learning models to improve students’ problem-solving skills is the PO2E2W learning model. The PO2E2W learning model is a self-regulated learning-oriented learning model to enhance problem-solving skills, [15] so that students can observe or monitor their own thoughts, feelings and behaviours in order to achieve a goal [16] to solve problems. The PO2E2W learning model has five learning stages, they are problem oriented, observation, explanation, elaboration, and write in science [15]. The PO2E2W learning model not only presents the learning process that helps students solving problems (due to scaffolding), but also facilitates the students to actively engage in interaction with friends of groups, friends of other groups and teachers through collaborative and cooperative learning and more learning that is oriented to the real problem in everyday life [15]. Previous research conducted by [15] suggested that the PO2E2W learning model is effective in improving problem-solving skills of junior high school students. The focus of this study is a follow-up study based on recommendations [15] to see the effectiveness of the learning model to improve problem-solving skills in different study materials and levels that is in grade 4 of primary school students. The results of this study are expected to be an empirical evidence of the PO2E2W learning model effectiveness to improve the problem-solving skills of primary school students.

2. Method

2.1. General background of research
This research was conducted at state primary school Kemayoran 1 (Madura, Indonesia). The scope of this research was the fourth grade of primary school students who take natural science subjects in academic year 2017/2018. The objective was to analyse the effectiveness of the PO2E2W learning model in natural science learning that was met by analysing the improvement of problem-solving skills of primary school students before and after the application of PO2E2W learning model. The effectiveness of the PO2E2W learning model was determined based on: (1) Significant increase in the score between the pre-test and post-test of the students' problem-solving skills, (2) The n-gain average is determined at least on the low improvement criterion, (3) The consistency of average n-gain score of the students’ problem-solving skills, and (4) Student response is at least positive enough.

2.2. Sample of research
The samples of research were 20 students at state primary school Kemayoran 1 (Madura, Indonesia) and it used purposive sampling technic; which the two groups, namely: group-1 (class IVA) and
group-2 (class IVB) had homogeneity of problem-solving skills. Each group consisted of students on natural science subject in academic year 2017/2018.

2.3. Instrument and procedures
The problem-solving skills of primary school students were measured by using the Problem-Solving Skills Assessment Sheet (PSSAS), which has been declared valid and reliable [10]. The PSSAS is structured on the basis of the measured problem-solving indicators: (1) problem representation, (2) developing solutions, (3) justifying proposed solutions, and (4) evaluating the solutions [3,4,15]. The used subjects of natural science lesson that were in this study were selected to be in accordance with the characteristics of the PO2E2W learning model, it was Force.

This study used one group pre-test and post-test design, O1 X O2 [17-20]. The learning began by giving pre-test (O1). Every primary school student was required to complete PSSAS. After the pre-test, the teacher applied the PO2E2W learning model and the natural science learning instruments to each group (X). The implementation of PO2E2W learning model has been done for five meetings on natural science subjects by using PO2E2W learning model that has syntax include: (1) problem oriented, (2) observation, (3) explanation, (4) elaboration, and (5) write in science [15]. The natural science learning instruments consisted of: syllabus, learning implementation plan, student activity sheet, textbook, PSSAS, and student response questionnaire (valid and reliable) [10]. Each phase of the PO2E2W learning model by design trains the problem-solving skills indicators include: (1) problem representation, (2) developing solutions, (3) justifying proposed solutions, and (4) evaluating the solutions. The implementation of PO2E2W learning model on natural science learning was ended by post-test (O2) by using PSSAS. Every primary school student was required to complete PSSAS on post-test.

2.4. Data analysis
The problem-solving skill of primary school students was analysed based on the assessment that was done before and after the application the PO2E2W learning model on natural science learning. Pre-test, post-test, and n-gain of the problem-solving skills were analysed by using inferential statistics with the help of IBM SPSS software 22. The N-gain was determined by using the equation: n-gain = (post-test score - pre-score -test) / (maximum score - pre-test score) [18-22], with criteria: (1) if n-gain ≥ .7 (high), (2) if .3 < n-gain < .7 (medium), and (3) if n-gain ≤ .3 (low).

The choice of statistical testing methods relied on fulfilling the assumptions of normality and homogeneity of variants for pre-test scores, post-test scores, and n-gain of the students’ problem-solving skills. The inferential statistical test with Paired t-test or Wilcoxon test (analysis of statistical improvement) and n-gain consistency analysis of all primary school students after the application of PO2E2W learning model on natural science learning used Anova or Kruskal-Walls test.

3. Result and discussion
The results of the PO2E2W learning model implementation on the natural science learning are presented in table 1, table 2, table 3, table 4 and figure 1 that will be explained as follows.

Table 1. Average pre-test, post-test and n-gain of problem-solving skills of primary school students in natural science lesson.

| Group       | Problem solving skills of primary school students | N-gain |
|-------------|--------------------------------------------------|--------|
|             | Pre-test  | Post-test |                   |
| 1 (Class IVA)| 40.10    | 79.20     | 0.58 Moderate     |
| 2 (Class IVB)| 46.40    | 77.80     | 0.66 Moderate     |

Table 1 describes the mean pre-test, post-test and n-gain of the primary school students’ problem-solving skills. The low pre-test value was because the students have not had problem-solving skills. In contrast, after the implementation of the PO2E2W learning model the score of students’ problem-solving skills increased. This increase was influenced by the tasks assigned during the learning.
process. The tasks assigned to students were the problems that occur in students’ life. In addition, the learning process presented the existence of scaffolding, in order to facilitate students in solving problems [15]. The results of this study prove that the implementation of PO2E2W learning model on natural science learning is effective in improving the problem-solving skills of primary school students. This is because the developed PO2E2W learning model meets the validity (content and construct), practicality, and effectiveness to improve the problem-solving skill of primary school students [10,15]. This is supported by the results of the study [1-5,12-13,18-21] that the model which is declared feasible by fulfilling the validity (content and construct), practicality, and effectiveness will be able to improve and achieve the learning objectives.

The results of the normality and homogeneity test of variance suggested that the pre-test, post-test, and n-gain of the students’ problem-solving skills were homogeneous and normally distributed for the whole group. Therefore, the impact of the PO2E2W learning model implementation to improve the problem-solving skill of primary school students for the whole group used Paired t-test and consistency test by using Independent t-test. Paired t-test and Independent t-test results are presented in table 2 and table 3.

Table 2. The results of Paired t-test of natural science problem-solving skills at all groups.

| Group       | N  | Paired t-test, α = 5% |
|-------------|----|-----------------------|
|             |    | Mean  | t    | df | p     |
| 1 (Class IVA)| 10 | -39.10 | 18.43 | 9  | .00   |
| 2 (Class IVB)| 10 | -31.40 | 9.02  | 9  | .00   |

Table 2 shows the average of natural science process skills for groups 1 and 2 are -39.10 and -31.40 and the t score gives t value = 18.43 and -9.02 for degrees of freedom (df) = 9 (groups-1 and group-2). Each score is considered significant, because p < 5%. Therefore, the t result of the calculation is negative, so it shows that there is an increase in students’ problem-solving skills after the application of PO2E2W learning model for all groups.

Table 3. The Independent t-test results of students’ problem-solving skills at all groups.

| N-gain_Group-1_Group-2 | t    | Df    | Sig. (2-tailed) |
|-------------------------|------|-------|-----------------|
|                         | -1.339 | 18       | .197             |

Table 3 shows that t arithmetic gives t < table with significance level P> 5%. This clearly indicates that there is no difference in students’ problem-solving skills after the implementation of PO2E2W learning model for all groups. Table 2 explains that there is a significant difference between pre-test and post-test (there is an increase) of problem-solving skills of primary school students in natural science learning. Table 3 shows that there is no significant difference (consistent) on the improvement of problem-solving skills of primary school students in the natural science lesson as the impact of applying the PO2E2W learning model to all groups. This is because the PO2E2W learning model has been developed by design to improve the problem-solving skill of primary school students in natural science learning through syntaxes of problem oriented, observation, explanation, elaboration, and write in science [15].

The results of previous studies [15] stated that the PO2E2W learning model is effective in improving problem solving skills for junior high school students. The results of other studies [23-24] stated that self-regulated learning strategies can significantly improve academic achievement. The results are reinforced by theoretical and empiric support that the PO2E2W learning model is supported by learning theories, namely motivational theory, cognitive-social constructivist theory and cognitive learning theory [25-27]. Therefore, PO2E2W learning model is effective to improve problem-solving skills of primary school students. The improvement of students’ problem-solving skills is reinforced by the qualitative data presented in figure 1.
Figure 1. Problem-solving skills after the implementation of the PO2E2W learning model.

Students in figure 1 get a score of 2 because the given explanation or argument was less in line with the concept of frictional force. Problem number 2 is a problem-solving question with the solution evaluation indicator. The student earned a score of 2 because the alternative solution proposed in the answer had nothing to do with the concept of frictional force. The improvement of students’ problem-solving skills was supported by PO2E2W learning instruments. The results [28-29] stated that there is an increase in students’ understanding by using SRL. Other results stated that the group that was given the training of SRL obtained higher academic achievement than those who did not get the training [30-31]. The improvement of students’ problem-solving skills after implementation of PO2E2W learning model supported by student response data that is presented in table 4.

Table 4. Response of primary school students to PO2E2W learning model.

| Response of primary school students | Group 1 (Class IVA) | Group 2 (Class IVB) |
|------------------------------------|---------------------|---------------------|
|                                    | Sample  | Response | Category | Sample  | Response | Category |
|                                    | 10     | 99.00%   | Very Positive | 10     | 94.00%   | Very Positive |

Table 4 shows that in general students responded very positively to the PO2E2W learning model and learning instruments. The interview results indicate that students feel that their problem-solving skills increase. The results of this study become an empirical evidence of the effectiveness of PO2E2W learning model on science learning to improve problem-solving skill of primary school students.

4. Conclusion

The PO2E2W learning model (problem oriented, observation, explanation, orientation, and write in science) is a self-regulated learning model that is designed to improve problem-solving skills. The results of the study prove that: (1) There is an increase in problem-solving skills of primary school students at $\alpha = 5\%$; 2) The average score of n-gain of the students’ problem-solving skill was in medium category; (3) There is no significant (consistent) difference on the natural science problem-solving skills in all groups; and (4) Students responded very positively. Therefore, the PO2E2W learning model on natural science learning has proven to be effective to improve the problem-solving skill of primary school students. Problem-solving skills are developed in students to prepare them to be successful in the future challenge. The implication of this research is that PO2E2W learning model can be used as a reference in improving students’ problem-solving skills in learning. Researchers suggest further research will be done at different levels of education and country.
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