Enhancing problem-solving skills of students through problem solving laboratory model related to dynamic fluid

A Malik¹, U A Yuningtias¹, D Mulhayatiah¹, M M Chusni¹, S Sutarno², A Ismail³ and N Hermita⁴

¹Program Studi Pendidikan Fisika, UIN Sunan Gunung Djati Bandung, Jl. A.H. Nasution No. 105 Bandung 40614, Indonesia
²Program Studi Pendidikan Fisika, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Bengkulu, Jl. WR. Supratman, Kandang Limun, Bengkulu, Indonesia
³Program Studi Pendidikan Fisika, Institut Pendidikan Indonesia, Jl. Pahlawan No 32, Taragong Kidul Garut 44151, Indonesia
⁴Pendidikan Guru Sekolah Dasar, Universitas Riau, Pekanbaru 28293, Indonesia

*adammalik@uinsgd.ac.id

Abstract. Problem-Solving Skills (PSS) is one of the skills needed to prepare the student to face the development of science that can support the world of work. This study aims to determine the improvement PSS of students after applied Problem Solving Laboratory (PSL) model on the dynamic fluid topic. The method used was pre-experiment with one group pretest-posttest design. The subject of the research was 30 students of class XI senior high school 27 Bandung. PSS of students was measured with student worksheet and essay test. The result of the study shows that based on the student's answer on the student worksheet there was an increase of PSS during the three meetings related to the topic of dynamic fluida. Average normalized gain <g> of PSS value of 0.60 indicates there was an increase in PSS of students of the medium category. The based result of paired sample t-test values of significance (2-tailed) of 0.000 < 0.05 indicated the use of PSL can enhance PSS of students. Thus, the PSL model can be used to improve PSS of students on the dynamic fluid topic. Finally, PSL could be applied in other topics of physic and increase another thinking skill.

1. Introduction

Physics evolves based on the integration of experiences based on observations of natural phenomena and on the concept of human understanding of nature [1]. The diversity of problems of integrating observation and human understanding of nature often leads to problems that require solutions. Students are required to skillfully solve problems systematically and determine solutions that are relevant to the problems encountered. Students need learning conditions that resemble such real situations in everyday life, meaningful and authentic learning experience through doing science [2, 3].

Problem Solving Skills (PSS) is a complex and very important skill as part of the learning process in all disciplines. PSS can be developed by students with the help of the teacher, the problem solved should be stratified and can be completed either sequentially or parallel [4-6]. PSS can be trained and developed for students through learning and laboratory activities. Students in laboratory activities make direct contact with the object of the problem. Laboratory activities are useful in enhancing high-
order thinking skills (critical, creative, problem-solving), scientific communication skills, scientific thinking, and training students in cooperative learning [7-16].

One of the practicum-based learning models for training problem-solving skills is the Problem Solving Laboratory (PSL). This PSL model consists of three learning stages, namely opening moves or pre-experiments; middle game (depends on the problem) or experimental stage; and end of game or post-experiment [17]. Previous research has shown the application of the PSL model can improve students' conceptual understanding [18], students' science process skills [19], creativity and student learning outcomes [20], students' metacognition ability [21] and students' procedural knowledge to solve problems [22].

The process of physics learning, especially the dynamic fluid topic in schools is still informative, focusing on the application of mathematical formulas for solving problems and lacking real experience and meaningful learning for students. Students mostly simply memorize concepts without understanding and proving empirically. Knowledge gained can not be applied to solve problems encountered with everyday life [18].

When fluid is in motion, its flow can be characterized as being one of two main types. The flow is said to be steady, or laminar if each particle of the fluid follows a smooth path, the velocity of fluid particles passing any point remains constant in time [23]. Above a certain critical speed, fluid flows to become the turbulent or irregular flow. The term viscosity is commonly used in the description of fluid flow to characterize the degree of internal friction in the fluid. Viscosity causes part of the kinetic energy of a fluid to be converted to internal energy [23].

The flow rate (volume flux) through the pipe is constant; this is equivalent to stating that the product of the cross-sectional area $A$ and the speed $v$ at any point is a constant. This result is expressed in the equation of continuity for fluids: constant [23].

$$A_1v_1 = A_2v_2 = \text{constant}$$  

One of the basic laws in solving the fluid problem is Bernoulli's law. Bernoulli's law is actually a law of mechanical energy applied to a moving fluid so that a typical out-of-shape equation exists [24].

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho gh_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho gh_2$$  

Therefore, research on the application of PSL to improve PSS of students is still rare. This study used pre-experiment method. Instruments for measuring PSS of student include student worksheets and essay tests. This study aims to determine the effect of using PSL in improving student PSS. This paper describes the results of the study associated with student PSS improvement after PSL applied to the topic of dynamic fluid.

2. Method

This research used the pre-experiment method that is research of one group of students without any control group with type one group pretest-posttest design. The population of this study was the entire class XI senior high school 27 Bandung, amounting to 6 classes. Sampling technique using random sampling technique and selected class XI IPA 6 as a sample of the number of students 30 people.

The instruments used in measuring problem solving skills in this study using student worksheets and essay test. Student worksheets is used to train PSS of students tailored to PSS indicators and PSL models so students can follow and understand the learning process. LKS contains three sub-topics of dynamic fluid consisting of the equation of continuity; the law of Bernoulli; and the application of the Bernoulli law. The test is used to determine the achievement of the indicators contained in problem-solving skills after the PSL model is applied. The student's PSS score and indicator indicator refers to the Docktor & Heller framework [25]. Based on the results of the research that calculates the results of student worksheet by matching the answers to learners with the key answers that have been made. The scores obtained are calculated and interpreted under the Arikunto framework [26]. The improvement students' PSS was shown by calculating average normalized gain <g> and interpreted into the category
Hypothesis testing is done by using parametric statistic paired sample t-test because after the second normality test normal distributed data. Hypothesis testing was performed using the help of IBM SPSS 20.

3. Result and discussion

Based on the results of the student's PSS improvement analysis in terms of sub-topics taught on the topic of dynamic fluid, students still find it difficult to understand the sub-topic of the equation of continuity. This is because the learning at the first meeting is not maximal and the new students learn with the PSL model so that the learning has not gone well. The equation of continuity that the product of the area and the fluid speed at all points along a pipe is constant for an incompressible fluid [23]. PSS of students on the Bernoulli law sub-topic experienced the highest increase because students in laboratory activities of legal sub-topics Bernoulli has understood PSL model and PSS of students have been trained and developed on previous learning. The Bernoulli law that the pressure of a fluid decreases as the speed of the fluid increases. In addition, the pressure decreases as the elevation increases [23].

Increased student's PSS in this study was assessed based on student answers on students' worksheets and the essay test. The result average PSS of students based on the answers to the student worksheet is presented in table 1.

| Table 1. The average of student's PSS is based on the answers to the student workshee. |
|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| No | PSS Indicators                      | Learning to- |
|    |                                     | 1 | 2 | 3 |
| 1  | Physics approach                     | 81.6 | 80.4 | 84.4 |
| 2  | Useful description                   | 54.6 | 72.9 | 80.3 |
| 3  | Specific application of physics      | 53.4 | 54.8 | 53.9 |
| 4  | Mathematical procedures              | 64.9 | 66.7 | 64.4 |
| 5  | Logical organization                 | 44.8 | 48.8 | 75.6 |
| Sum|                                    | 299.4 | 323.5 | 358.6 |
| Average|                                | 59.9 | 64.7 | 71.7 |
| Interpretation |                         | Enough | Enough | Good |

The average of each student's PSS indicator on each learning has increased. Although in some PSS indicators students have decreased to the second lesson then climbed back on the third lesson. The average PSS of the students as a whole based on the answers to the students' worksheets have improved on the learning of the first until the third is good categorized.

The results of the student worksheet analysis showed that there was a decrease in scores of the physics approach indicator at the second learning and increased again to the third learning. The occurrence of the decrease and improvement to the student worksheet scores on the physics approach indicator shows that students have not been able to determine the physics approach used in different problems consistently and appropriately. The average result of the score are well categorized. Students' knowledge structures are usually less organized, it would be useful if the guidance provided helps them builds a strong and well-organized hierarchy of knowledge [28].

The distribution of students' PSS scores based on the assessment of essay test answers can be demonstrated by comparing the mean scores of pretest, posttest, and average normalized gain <g> is shown in table 2.

| Table 2. Scores of pretest, posttest, and average normalized gain PSS of students. |
|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Scores                              | Pre-test | Post-test | <g> | Interpretation |
| Sum                                 | 665      | 2064      | 0.60 | Medium         |
| Average                             | 22.20    | 68.80     |      |                |
The improving student's PSS after being applied PSL model on the dynamic fluid topic included in the medium category with $g_0$ equal to 0.60. The average value of student's PSS of pretest 22.10 and the average value of posttest 68.80 occurred an increase in 46.6. Therefore, there is an increase PSS of students after the application of PSL model on the dynamic fluid topic.

The average score of pretest, posttest and average normalized gain scores of indicator PSS of students is shown in table 3. Each indicator PSS of students has improved on the including medium category. The average normalized gain of student's PSS indicators indicate included in the medium category. The average normalized gain of useful description indicator was the biggest improvement while the lowest occur to the physics approach indicator.

### Table 3. The average of average normalized gain scores of indicators PSS of students.

| No | PSS indicators                  | Pre-test | Post-test | $g_0$ | Interpretation |
|----|--------------------------------|----------|-----------|-------|----------------|
| 1  | Physics approach               | 23.20    | 64.50     | 0.54  | Medium         |
| 2  | Useful description             | 35.30    | 79.50     | 0.68  | Medium         |
| 3  | Specific application of physics | 22.50    | 68.00     | 0.59  | Medium         |
| 4  | Mathematical procedures        | 12.50    | 64.17     | 0.59  | Medium         |
| 5  | Logical organization           | 19.70    | 67.83     | 0.60  | Medium         |
|    | Average                        | 22.60    | 68.80     | 0.60  | Medium         |

The average normalized indicator of useful description indicator was the students' greatest increase after the PSL model was applied. Students can describe a problem comprehensively and select useful information to solve the problem. This result is also supported by the results of the student worksheet analysis showing that there is a continuous increase in useful descriptive indicators from the first to the third learning. Learning by applying the theory through laboratory activities can improve the ability of the process, the ability to solve problems and interests and attitudes of students to learning [29].

The physics approach indicator becomes an indicator of problem solving skills with the lowest score. Students have not been able to explain the concept of physics, just memorize the mathematical formulas for understanding the concept. Teierrmayer [30] says students often do not pay attention to the relationship between the real world and the subject of physics, so they only aim to practice the laws and formulas that have been studied.

One of the most important components in solving problems is knowing and understanding the basic principles of physics. The basic principle of physics can lead students to analyze the problem, because if students do not understand the basic principles it will tend to make mistakes when solving the problem. The results of the student worksheet analysis also showed that there was a decrease in the scores of the physics approach indicator on the second learning and increased again to the third learning. Students have not been able to determine the right physics approach to be used on different problems. Laboratory activity with problem-based laboratory instruction trains students to make measurable changes in problem-solving skills and metacognition. [31].

The result of normality test of PSS data of students using One-Sample Kolmogorov Smirnov Test shows pretest and posttest data are normally distributed on the significance of 0.114 and 0.072. The result parametric statistical tests ($t$-test with $\alpha = 0.05$) for paired sample $t$-test result showed that the implementation of PSL model can significantly enhance PSS of students. It is based on the result of value significance (2-tailed) was $0.000 < 0.05$. The results of this study strengthen before, students' problem-solving skills increased after using student worksheet oriented the problem solving [32]. Sujarwanto et al. [33] reveals that providing complex and contextual problems will help students in improving their problem-solving skills physics.
4. Conclusion
We have successfully researched the application of the problem-solving laboratory model in enhancing the problem-solving skills of students. The improved student’s problem-solving skills were including the medium category. Therefore, to be able to improve problem-solving skills, students are advised to reading and summarize the topics to be studied first before applying the lesson to the problem-solving laboratory model. Teachers should provide clear guidance of students about the activities to be performed. Teachers also remind students of the initial purpose of the laboratory activities carried out because the objectives are closely related to the conclusions.

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