Experiential learning using STEM approach in improving students’ problem solving ability

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Abstract. This study aims to explore the increase of students’ problem solving ability as the impact of the application of experiential learning using STEM approach. This study use a pre-experiment method that is applying the one group pretest-posttest learning design. The participants are 40 students (18 male and 22 female) of second grade Science program in one high school in Province of West Java. The selection of the participants is using random class sampling technique. The data are collected based on the questions that are given to the participants. The questions are divided into five indicators of problem solving ability in Pascals’ principle learning material. According to the result of this study, that using normalized gain, it shows the increase of students’ problem solving ability that can be categorized in high level. The highest score for the students’ problem solving ability is in describing problem and planning a solution, whereas the lowest score is in giving evaluation for the solution of the problem. The result of this study shows that the experiential learning using STEM approach can be used as an alternative to improving students’ problem solving ability, especially in Pascals’ principle.

1. Introduction
Physics is a subject that underlies the development of advanced technology and the concept of living in harmony with nature. The function of the subject are developing experience, understanding the concepts and applying the concepts in order to solve problems in everyday life as well as developing science and technology especially for high school students. Explicitly, the purpose of the subject is focus on the students ability to solve some problems.

Problem solving is an important aspect in science learning. In physics learning, problem-solving is an essential component and plays a central role [1],[2]. Problem solving is an attempt of a person or group in order to find answers based on knowledge, comprehension, and skills which are people have in order to meet the demands of a situation that was unpredictable [3]. With this intention that problem solving is to conduct a procedural step by step systematically, in an attempt to find a solution to solve the problem by using students thinking skills. Therefore, a learning process which is intended to train problem solving skills should require the appropriate learning design.

Experiential learning is a learning process that encourages students to be enthusiastic and make the experience as the foundation [4]. However, experiential learning has not emphasized the application of science and technology to solve problems in the real daily life. As a result, the experiential learning can be combined with Science, Technology, Engineering, and Mathematics (STEM) approach in order to make students better understanding and more importantly, they can apply their knowledge in the daily activities [5].
STEM approach refers to the combination of science, technology, and mathematics concepts. Learning process which is using STEM approach can give students a learning experience, active learning and contextually meaningful [6]. The application of STEM approach in learning process encourages students to develop and share new knowledge and train the problem solving skills to solve problems in daily activities [7]. According to the previous research, there were significant increases in participants science knowledge after they were applied to the STEM approach [7]. Students showed high motivation to learn STEM subject [8]. Likewise, the integrated program in interdisciplinary STEM algebra/science can improve students problem-solving skills [9]. Although, there was no significant difference between students who received the STEM integration and students who get algebra course without STEM approach [9].

STEM approach is an integrated learning approach. In other words, this approach is a combination of scientific process learning with the engineering process learning. In this study, STEM learning application is limited to focusing on real-world issues, ask questions (sciences) and define the problem (engineering), as well as engineering design process (design, construct, and test).

The expected purpose of this research is to explore high school students problem-solving ability improvement as a result of the application of experiential learning using STEM approach to the Pascal’s law principle learning material. For the most part, the question is how to increase problem-solving ability of high school students on Pascal’s law principle learning material as a result of the application of experiential learning using STEM approach?

2. Methods
This study is a quantitative research that is using pre-experimental designs, one group pretest-posttest. In this design, the participants are given a pretest. Then, the participants are learning using the experiential learning model during two times. Finally, the participants are given a posttest. The use of this research design is in order to obtaining the data regarding the impact of a treatment that is applied to the participants to the dependent variable, not to the test its effectiveness compared to other treatments [10]. The dependent variable that mentioned above is the problem solving ability. On the other hand, experiential learning using STEM approach is the independent variable.

| Pretest | Treatment | Posttest |
|---------|-----------|----------|
| X       | O         | X        |

The participants of the study are 40 students in second grade high school, especially in Science program, in one school in the Province of West Java. The students consist of 18 male and 22 female which have average age 17. This selection of the participants is using the random sampling technique which is possible to not changing the formation of the participants, students in a class that already exist. With this sampling method, take one class randomly as a group, and then consider it as the participants of research.

The instrument of this study is the test of problem solving capabilities in the form of closed-description questions. The questions contain the five indicators of problem-solving abilities. Those indicators are the ability in focusing the problem, describing the problem, planning a solution, using the solution, and evaluating the solutions [11]. Analysis of the results in this research data was normalize gain (N-Gain) of the pretest-posttest score.

3. Result and Discussion
Based on results average score pretest 3.45, average score posttest 11.68, and gain score 8.23. According to the result of this study, that using N-gain, it shows the increase of students problem solving ability is 0.71 and that can be categorized in high level.
Based on Figure 1, we can see that the highest score for the students' problem solving ability is in describing problem and planning a solution. The N-gain in describing problem is in the amount of 0.86, and planning solution is in the amount of 0.84, while the lowest increase of problem-solving is in evaluating the solution which is amounted 0.52. It is assumed that this kind of learning method encourages the students to describe the problem. The students are expected to understand the problem before they start to solve the problems. The problems that are given to the students are based on their daily experience. The ability to describing the problem using has been trained at the concrete experience stage. At this stage, the teacher is a facilitator who guides the students to be focus on the problem and describe the problem based on the issues which are familiar or experienced by the students. Also, both students and teacher are actively participate in this stage. This is also strengthened by an average of descriptions of students on the worksheets.

Based on students’ worksheets, it shows that students can describe the cause of a flood. For instance, they describe the cause of flood is a large piles of garbage in the river that block the flow of the river. In this case, this example answer shows that the students are trained to be able to finding, focusing, and describing the problems that are encountered in their daily life. Moreover, students are motivated to find a solution to the problems. As a result, students are very enthusiastic to participate in the learning process [11].

Also, the students ability in planning a solution is increasing high. Planning a solution is trained in abstract conceptualization stage. At this stage, the training of planning a solution is amplified using STEM approach. Students are doing the engineering process to planning solution. The planning solution activity that the students are supposed to make is a simple tool that can move an object that is utilize the of the Pascal’s law’s principle application. The Pascal’s law’s principle stated that even if the force \( F \) is small, it can produce a large force by considering the surface area \( A \) which is subjected by the force. The principle is used in designing the hydraulic arm, in other words, it can be called as excavator. The design of the hydraulic arm that has been created by the students can be seen in Figure 2.

Compare to the describing indicator, the score of evaluating solution ability obtain the lowest amount of the problem-solving capabilities. It is in the amount of 0.52. In the evaluating solution stage, the students are encouraged to be involved in an experiment and encourage the students to find the solution that they have made. Teachers orally guide the students to evaluate the solutions. Then the students need to evaluate whether the solution they have made is in accordance with the problems they encounter or not. Unfortunately, this case is only applied to a group that presents their presentation. This can be one of the factors that makes the low score in evaluating solution.
Based on our findings, another factor that may cause the low increase in evaluating solution is that the form of the test. It is in the form of a structured description questions. Unfortunately, the disadvantage of a structured description question test is the student should be able to answer the question above before they answer the next questions. In reality, the evaluating solution skill is proposed in the final question. Therefore, the results obtained that the evaluating solution ability reach the lowest score among other indicators because evaluating solution ability score depends on the students’ answers to the problems in the early questions but their capability in evaluating solution is decided in the final questions.

4. Conclusion
In the final analysis, it can be conclude that the application of experiential learning using STEM approach can highly enhance high school students problem solving ability. The average score of the N-Gain increase is in the amount of 0.71. Specifically, the highest increase is in describing the problem that obtain 0.86, while the lowest increase is in evaluating solution that contain 0.52. Recommendation for further research is effectiveness STEM approach in improving students’ problem solving ability in other topics.

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