Plan your own science experiment: Elaborating students’ creativity and problems in science laboratory activity

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Abstract. In general, science class is usually accompanied by science laboratory activity. Conventionally, when students do their science laboratory activities, they follow science laboratory manuals where fixed steps of the activities are already provided. Alternatively, open-ended science laboratory manual can be implemented. In this study, the concept of Plan-your-own-science-experiment was applied. For this descriptive research, 65 primary-school teacher candidate students, which were divided into 8 groups, were asked to do an experiment about the effect of carbonated beverages on balloons with a simple open-ended laboratory manual. The guidelines only suggested the materials and apparatus required for the experiment, as well as a simple step to do the activity. The students were expected to broaden the possibility of the experiment with the same materials and apparatus recommended on the lab manual, and submit reports about their self-planned experiments. Afterwards, the students reports were elaborated for exploring students creativity emerged in the experiments they planned by themselves, and also scrutinizing the students problems in creating their own laboratory activity steps scientifically with an unstructured laboratory manual. The students’ creativity and problems found in their reports were discussed in this study. The results were supposed to provide science-teachers insights about positive sides and difficulties in applying Plan-your-own-science-experiment in science laboratory activity.

1. Introduction

Having laboratory activity in science class is something which is generally accepted to enhance students’ skill in science. It is said that the laboratory is an important part of science education, and science teachers admitted that there are many benefits that could be reached in science learning using laboratory work [1]. Therefore, it might be presumed that laboratory activity in learning is inevitable [2]. Laboratory activity may facilitate students to understand science as the process of problem solving [3]. Moreover, science laboratory activity is assumed to enhance students’ motivation in learning science, as well as to improve their scientific attitudes [3].

There are several goals of laboratory activity, which are (1) scientific concepts understanding; (2) interest and motivation towards science; (3) scientific attitudes; (4) scientific practices skills and problem solving ability; (5) scientific thinking ability; (6) understanding of nature-of-science (NOS); and (7) the opportunity for really “doing” science [4]. Furthermore, National Research Council [5] stated that having experience in a laboratory may provide opportunities for the students to interact with the real world (or with data from the real world) by using apparatus, data-collecting techniques, and scientific theories. In addition, National Research Council [5] expressed that laboratory activity may bring some
benefits such as (1) improving students’ mastery on scientific concepts; (2) enhancing the ability of scientific thinking; (3) helping the understanding of empirical work complexity; (4) improving practical skill; (5) helping the understanding of nature-of-science (NOS); (6) raising the interests towards science and science learning; (7) improving teamwork ability.

Thus, it can be seen from the previous explanation that science laboratory activity brings abundant benefits. However, from those several usefulness of laboratory activity, it is not said yet that laboratory activity may also enhance the students’ creativity. This study suggests one particular way called “Plan Your Own Science Experiment (PYOSE)” that is presumed to be able to improve students’ creativity and common sense. This paper elaborates the impact of PYOSE not only to the students’ creativity, but also to the problems raised from the implementation of PYOSE.

2. Methods
This study was planned to find the impacts of PYOSE to the students’ creativity in laboratory activity and the problem that may rise by using PYOSE. This study was conducted at a university in Indonesia with sixty-five primary-school teacher candidate students divided into eight groups. This study is a descriptive research as it is said that recognizing the accomplishment of some groups of students is categorized as a descriptive study [6]. The students involved in this study were asked to do an experiment about the effect of carbonated beverages on balloons with a simple open-ended laboratory manual called PYOSE. PYOSE is the way of doing experiment with no certain procedure. The students may broaden the procedure of the experiment by themselves.

It is known that in standard science lab work, the sections expected to be explained on the written reports are (1) goal of the experiment; (2) theory that should be mastered to do the experiment properly; (3) materials and apparatus needed for the experiment; (4) procedure of the experiment (which is done by the students); (5) discussion; (6) conclusion. Commonly, the procedure-of-the-experiment part is given by the teacher or it is already stated in the laboratory manual book, so that the students merely need to follow the certain procedure. However, nowadays, in digital era, science learning by inquiry could be renewed in some way [7]. It also said that inquiry-based laboratory activities (with specific steps) may improve students’ understanding of nature-of-science (NOS) [8]. As one of the way to actualize the inquiry process of science learning, PYOE was suggested. In this study, PYOSE offered more flexibility to the procedure-of-the-learning by inquiry could be renewed in some way (How part). Instead of directly given restraint procedure of the experiment to the students, with PYOSE, students may vary the procedure in their own way, as long as it is regarded as varying only-one variable, and other variables are presumed constant. On other words, students made their own procedure of the experiment and were expected to broaden as many as possibilities from the experiment.

The main procedure of the experiment was opening a bottle (or some bottles) of soda, following by putting a balloon over the neck of the bottle [9]. Then, the students were asked to observe what happened to the balloon. The rest of the procedure was determined by the students themselves.

After finishing the experiment, the students wrote the laboratory activity reports. Next, the reports were analyzed, especially on the students’ creativity and problems that were noticeable from the report.

3. Results and discussion
The discussion of this paper elaborates the students’ creativity and problems related to the implementation of PYOSE.

3.1. Findings about students’ creativity
By doing PYOSE, it is quite captivating to see that students could reach some sorts of creativity which is not optimally offered by standard procedure of experiment. Some of the students’ creativity found were explained as follows.

First, it can be seen from the students’ reports that some groups used quite many variations of experiments. The students varied the temperature of the soda bottle. Some soda bottles were refrigerated, when the others were not. Then, the students observed the effect of the soda bottle to the balloon fitted
to the bottle neck for both soda bottles. Beside that, there were also some varieties of the numbers of times the bottle was shaken, the soda brand, the mixtures (one group compared salt-added soda with pure soda). It is noticed that the original needed-material offered by the manual did not include salt. Adding salt to the material for this experiment was purely the creativity of the student to broaden the possibility of making deduction from the experiment. It can be said that the students’ creativity here appeared well. Students might modify the experiment as broad as they could imagine, as long as it follows common sense and as long as there is only one-variable varied, and other variables remain constant.

Second, with PYOSE, although there is no restrained manual procedure for the experiment, the students were found to record detailed-writing quantities in their reports. The example of this kind of creativity found in their report could be seen in Table 1.

**Table 1.** Part of written report of students (translated from Bahasa Indonesia) completed with detailed-writing quantities about the balloon measurement in experiments applying PYOSE, with three-variations of experiments.

| Brand of soda | 1st experiment | 2nd experiment | 3rd experiment |
|---------------|----------------|----------------|----------------|
|               | circumference  | height         | circumference  | height         | circumference  | height         |
| A             | 17.1 cm        | 5.1 cm         | 18.7 cm        | 6.5 cm         | 21.1 cm        | 9.3 cm         |
| B             | 21.1 cm        | 9.1 cm         | 23.5 cm        | 10 cm          | 24.1 cm        | 11.1 cm        |
| C             | 25.8 cm        | 13.5 cm        | 27.1 cm        | 14 cm          | 27.4 cm        | 14.5 cm        |

The exact quantities that should be measured were not given in the manual procedure. The students should think by themselves about what information they can gather from the experiment. It was clearly enough that the change of the balloon quantity measurement was one quantity that should be observed, but somehow the students should notice what physics quantity that can represent of balloon measurement in the most correct way. For balloons with nearly-sphere shape, actually the measurement should be about the volume of the sphere, which was not easy to measure precisely. Therefore, the student should figure out what quantities that they can measure directly. In Table 2 it can be seen that one group could deduce that they needed to measure the circumference and height of the balloon. These quantities were regarded to roughly represent the volume of the balloons.

The other finding about students’ creativity was that some students could notify the ‘distinguishing variable’, and wrote it down in the laboratory activity report. These students were already aware of a specific variable that could be varied and named it directly as ‘distinguishing variable’ (which was the independent variable). Although in the process of the experiment the students were not fully-guided, some of the students were already mindful of that only one variable could be a ‘distinguishing variable’ (or independent variable), and they should let other variable constant while the experiment was done.

### 3.2. Problems found in students’ laboratory-activity report

Unfortunately, besides enhancing the students’ creativity, science laboratory activity with PYOSE also resulted some problems that can be noted from students’ report.

First, without fixed clue on the procedure, some students just wrote the measurement result without any unit. This is a very simple mistake, but at the same time it is also a fundamental error. Numbers without units could mean anything in science.

Second, there were still many writings of the students on their reports that they measured the balloons, but it was not clear what quantity that they measured. One example of the students’ report containing of this problem could be seen in Table 2. The lack of information of quantities that should be measured in the procedure manual might lead the students to just measure any quantities without any consent of the importance of knowing which quantities that are really needed to measure in order to have adequate data. Meanwhile, actually the students had to try to get adequate data, so that they could make right
conclusion from the data. From table 2 it can be seen that “balloon measurement 30 cm” might mean anything. It was unclear whether it was diameter, circumference, height, or else.

**Table 2.** Part of written report of students (translated from Bahasa Indonesia) in experiments applying PYOSE with unclear quantities describing the measurement of the balloons.

| Brand of soda | Balloon measurement |
|---------------|---------------------|
| A             | 30 cm               |
| B             | 42 cm               |
| C             | 20 cm               |
| D             | 23.5 cm             |
| E             | 26.8 cm             |

The other finding about the problems of using PYOSE is the lack of students’ awareness to make sure that only one variable that can be change in this experiment, and the other variable should remain constant (or at least nearly constant). All students in their experiment reports neglected the importance of the expiry-date information of the soda bottles they used. Actually, without the information about the similarity of expiry-date for each bottle of soda, it meant that the whole experiment missed informations about one main quantity. If there is no information about the expiry-date, students could not infer which brand are more ‘gaseous’ because the expire-date of the soda might not be constant. The students should be very careful in making inferences from the experiment.

4. Conclusion

From this study, it could be concluded that if it is compared with laboratory activity with fixed-procedure experiment, PYOSE broadened the opportunity to the students to be more creative in conducting experiments. On the other hand, there were still problems raised by allowing students planning their own experiment procedure. One main problem that has to be paid attention to is that students may not aware that for doing the experiments, they may vary one-variable only when other variables are constant.

Therefore, to minimize the problems that appeared in implementing PYOSE, teachers may lightly guide students in doing experiments in order to make sure that the students only vary one-variable. Moreover, it is highly suggested that teacher may provide extra time in class to give feedback on students’ reports and discuss the problems found, so the problems would not reoccur in the following experiments.

In addition, as a variety for students to write their own experiment procedure, it is possible to plan a lesson where students write the experiment manuals for their peers (not for themselves) [10]. This variation might generate more discussion in class, as long as the alloted time to do the experiment and discussion is sufficient.

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