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Indonesian physics laboratory: Learning physics concept through photovoice

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ABSTRACT

The laboratory is a centre and a place that is representing the characteristic of science as a process through laboratory activity. As a process, scientific approach can't be separated from laboratory activities. To understand the real laboratory, especially in a physics laboratory, we conducted laboratory activities by observing them through Participatory Action Research (PAR) as a research method. The role of PAR's member is a co-researcher and co-observer. Totally, 90 pre-service physics teachers from three classes in a public university in Surabaya contributed as PAR members. From these members of PAR, some data can be captured by using photovoice that it can be easier to describe the condition of the real physics laboratory. The results of the study illustrate three themes of imaging physics laboratory in Indonesia: (1) the condition of real physics laboratories in Indonesia, (2) the readiness of tools, materials, and procedural laboratory activities and (3) The comparison of the physics concepts among students through experimentation and theoretical ways.

1. Introduction

Digital games are widespread in educational settings. In the mean- while, digital games have been paid much attention by academic scholars (A half-century ago, scientists began to have a picture of the dividing walls of the work, now called laboratories (Latour, 1983). Natural laboratories are the real world of work, but some scientists are reluctant to go directly, besides being supported by special conditions of equipment that cannot be used outdoors.

In the development, laboratories are the cenre and characteristic of science (Hofstein & Lunetta, 2003; Mubarok, Lutfiyah, Kholiq, Suprapto, & Putri, 2018; Wiratma, & Subagia, 2014). Changes in terms of space and tools used have begun to be noticed, other than that in the laboratory activities. Various versions have been introduced over the years, numerous investigators have reported on the validity to assess the physical activity in the laboratory and field settings (Kelly, McMillan, Anderson, Fippinger, Fillerup, & Rider, 2013).

The laboratory is the right mode for developing scientific work. Generally, the process (scientific work) conceded by researchers in carrying out scientific work includes the following steps: (1) observing existing phenomena (library exploration); (2) asking the question why the phenomena occur (formulating the problem); (3) make a hypothesis to answer the problem raised or explain the reason; (4) planning an experiment and conducting experiments to test the hypothesis; (5) draw conclusions whether the hypothesis is correct or not based on experiments conducted (Suparno, 2006). The laboratory becomes a learning experience so that researchers or students interact with laboratory equipment directly.

Various types of research stated that laboratories are very petrified in learning activities, especially in science lessons. In this case, it is more specific in the field of physics. Physics is a science that requires observation and measurement carried out through experiments. Observation of natural phenomena is done by observing and analyzing the causes and effects of factors that are interrelated and influenced (Sani, 2012). Limited experiments can be carried out in a laboratory with good management and control. Meanwhile, in Basori's research (Hayat & Yusuf, 2010) which is about laboratory activities based on problem solving can improve students' science process skills, also encourages the acquisition of practical abilities (Okebukola, & Ogunniyi, 1984; Rakhmawan, Setiabudi, & Mudzakir, 2015) and understanding concepts in science (physics) and its applications (Hofstein & Mamlok-Naaman, 2007).

Through laboratory activities, students can study the truth of concepts learned theoretically through critical analysis based on their intellectual abilities. The most prominent issue in learning in the laboratory is the quality management problem of the laboratory, which includes the process of procuring, using, maintaining tools, and materials (Wiratma & Subagia, 2014). In this case, especially in Indonesia, the question is how about the readiness and ability of teachers and laboratory assistants in preparing tools and materials for carrying out laboratory activities (Tobin, 1986).

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To illustrate how the actual condition of the readiness and capability of a laboratory and its activities, photovoice is a proposed method. In practice, photovoice combines the results of photographs or documentation of individual and group actions through surveys, focus groups, nominal group processes, and other methods (Herbert, Baize-Ward, & Sutton-Brown, 2014, Latz, 2018; Wang, 1999).

In this study, through those methods, it is expected to find out (1) the condition of real physics laboratories in Indonesia, (2) the readiness of tools, materials and procedural laboratory activities and (3) the comparison of the physics concepts among students through experimentation and theoretical ways.

2. Methodology

The research design used a descriptive qualitative with participatory action research (PAR) method. Additionally, we used a photo-elicitation method to get the data through documentation and voice of respondents. Participants of the study consisted of senior students as pre-service physics teachers (PSPTs) from the public university in Surabaya that follows the teaching practice program (PLP program) as "a community practice" (dos Santos & Arroio, 2016). There were 90 PSPTs joined to the study as PAR member. Starting from the focus group discussion (FGD), the PAR members have continued to PLP program and interacting with respondents. The respondents of this research are teachers and senior high school students in several areas of East Java, Indonesia. The research is concerned with tools and materials inside the laboratory, laboratory activity, the procedural to conducting an experiment and the topic of laboratory activity in physics subject. Fig. 1 illustrates the process of data collection.

The photovoice method used in this study not only captures laboratory conditions and activities, but it also provides innovative and reflective methods to show these values to the community of academics about the laboratory. The research takes a unique and exciting method to "voice" the views of teachers and students in responding to laboratory conditions and classroom learning using digital technology (Baldwin & Chandler, 2010).

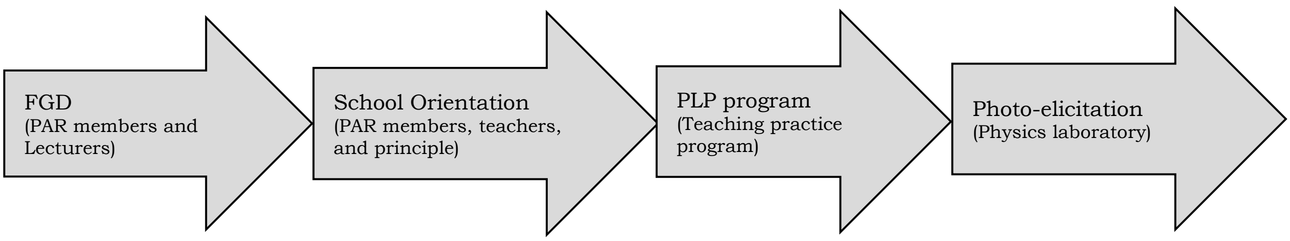

Fig. 1. Data collection process.

3. Results and discussion

In this research, we divided three themes to describe physics laboratory based on the photo captured through photo elicitation.

Theme 1: The real condition of Physics Laboratory in Indonesia

The laboratory is a learning media for student activity. There are several conditions of the laboratory in Indonesia, from unfit conditions to use until good condition with complete tools and materials.

Fig. 2. Unfit condition laboratory.

The figure illustrates the physics laboratory after being hit by a natural disaster (Fig. 2), which has not been repaired and remains in bad condition. The concern of school headmaster and teachers is needed to improve laboratory space to be better and more suitable to use. Building renovation needs to be done, for student learning activities can be maintained especially in science topics that require a laboratory as an interactive learning media to conducting laboratory activity.

Generally, high schools in Indonesia have a laboratory, especially in big cities. Each school has a different condition of the laboratory. If we compare the school laboratory to the university laboratory, such as fundamental physics laboratory, it is almost same with science or physics laboratory in high school. Usually, universities physics laboratory have more complete tools and batter management.

Fig. 3. Good condition and comfortable laboratory.

Good management laboratory has good saving the tools, a large room, and regular tool storage will make it easier to conduct laboratory activities and control it. As figure out in Fig. 3 and Fig. 4, tools setting is needed, the layout of each tool needs to be noticed. For example, to conducting electricity experiment using electric current, so have to close with stop contact or battery. Meanwhile, the laboratory should have storage cabinets for bags, to manage an object on the table of the experiment.

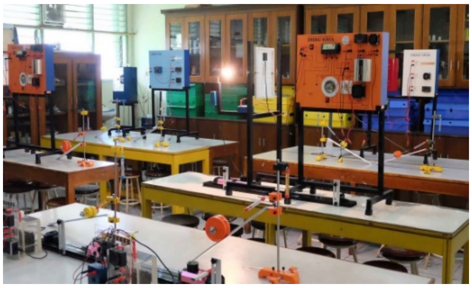

Fig. 4. Excellent condition and comfortable laboratory with complete tools.

Fig. 5. Bag storage cabinets.

Based on the interview process with teachers and students, the condition of the laboratory is useful but rarely used for laboratory activity. Although the physics curricula suggested the use of laboratory activity, it is only several topics that conduct laboratory activity. This is depending on the time and teacher management learning. Some teachers prefer to explain and activities in the class then conduct laboratory activity.

Theme 2: Inside the physics Laboratory

1.Topics

In this section, we focused on four topics for physics subject: mechanic, thermodynamic, optic, and electricity. Several students can do all the issues in laboratory activity with little guided by the teacher. But, a part of student can't do laboratory activity with their team. They always need guiding for each part in laboratory activity.

On mechanic topic, most students can do their activity with little guided. For the first step, teacher or assistant laboratory conducting laboratory activity for an example, and then continued by the student to do it as the teacher has done. The subtopics in a mechanic are density, free-fall motion, regular straight motion, circular motion, friction, oscillation, spring, Newton's law, the centre of mass, and pulley system. For mechanic topic, commonly in high school physics laboratory and university physics laboratory do all of subtopics mechanic, except the school that conducting laboratory activities one subtopic of each semester.

In thermodynamic topic, a little student can do perfectly to get good data, and another part can do laboratory activity with lots guided. In this topic, need a long time to conduct laboratory activity to get data. The thermodynamic topic usually conducted in the university laboratory. Therefore, it is a little high school that used this topic to carry out laboratory activity. Besides that, the teacher and assistant laboratory do not have a good patient to get the data; they have difficulty controlling the temperature. The subtopics of thermodynamics are the application of thermometers, heat types of solids, heat of melting, and calorimeter.

The easiest topic for conducting laboratory activity is optic. The subtopics of optic are light reflection, light refraction, light refraction, lenses, and diffraction grating optical instruments. With using a mirror or lens, the student can get the data. These sub-topics used in high school and basic physics laboratory in the university. For expand the concept, in physics Laboratory University used optic tool combine with computer-based data. The tools that used more expensive, so little high school which is has those tools.

Totally, woman physics teacher more than man physics teacher. Based on the interview, there are many woman physics teacher often to using electricity tools, although used low electric current most of them steal afraid to use the tools. The subtopic commonly using in high school are Multimeter, Ohm law, and Kirchhoff law. Meanwhile, in basic physics university laboratory using more than high school subtopics, as like wire type obstacles, Wheatstone bridges, RL and RC circuits.

2.Procedural

High school physics laboratory and university physics laboratory have a different procedure for conducting laboratory activity. In high school, the teacher gives several instructions and give an example and then student conducting laboratory activity likes teacher' have done. But, in university student get a pre-laboratory test. Lecturer or laboratory staff wants to know how students have mastered the use of tools, ways to get data and analysis. Need enough time to do the pre-laboratory test because the student should learn about the concept and use the tools for each topic.

Different level causes different behaviors to conduct an experiment. High school need to be guided inquiry each step to get the data but in the laboratory university only a few steps which needed the guide, because they have done the pre-laboratory test. There are several points for assessment in the university physics laboratory, (1) the ability to set tools correctly, (2) the ability to use and read the scale of the measuring instrument properly and (3) the cooperation among group members (Mubarok et al., 2018).

After conducting a laboratory activity, the student should be finishing the report. For high school, the report of laboratory activity is combining with worksheet conducting laboratory activity. But, in university report of laboratory activity is different from the worksheet. The student should be writing from chapter one: introduction, chapter two: literature, chapter three: method, chapter four: data and analyses, chapter five: conclusion and references. The report should write each topic of laboratory activity.

3.Tools

The variations of laboratory tools and materials are helpful in the school condition, teachers and laboratory staff. The majority of favorite schools are better equipped; they can buy

Fig. 6. The tools are ready to be used(a).

Fig. 7. The tools are ready to be used(b).

several laboratory tools as education media. But, depending on teacher and laboratory staff. Many schools have a good condition of the laboratory tools, but they are often to use, even the tools never used.

The good condition shows that the management laboratory is well. For example, likes Fig. 6 and Fig. 7, there are several tools to measure the length and the mass of the object. The tools are ready for using a measured object. Besides the tools that are ready at the table to conduct the laboratory activities, several tools and materials that are still stored as reserves, even if the ready tools are damaged, so they can use a backup tool as a substitute, like Fig. 8.

Fig. 8. Backup tools.

Management tools are needed. There are three conditions of the tools, (1) ready to use, (2) reserves and (3) broken. If the condition of the tool is not considered, students will use an improper tool, often in laboratory activities, students use tools that are not functioning normally, especially measuring instruments, so that the data obtained is inaccurate. Fig. 9 shows that three conditions of mass measurement tools (O'hauss). Besides, we need a variety of measurement tools, to compare the result data, where is the device which has proper calibration and level of accuracy (Fig. 10-12).

Fig. 9. Three conditions of the tools, (a) ready to use.

Fig. 10. Three conditions of the tools, (b) reserve.

Fig. 11. Three conditions of the tools, (c) broken.

Fig. 12. Good condition with complete tools.

Theme 3: Physics experiment and theoretical approach-Student paradox in laboratory

Physics experiment and theoretical approach are inseparable things, like complementary currencies, as if they were separate, but they are one. Physics experiments are carried out in a laboratory or in nature, to find out the actual knowledge of physics directly. In addition to experimental activities, a theoretical approach is needed to provide students with full understanding. They understand the real physics experiment and the physical meaning of the physics phenomenon. Additionally, they know the mathematical sense of data obtained from the physical aspects of investigations.

Fig. 13. Learning in classroom.

Fig. 14. Physics laboratory activity.

Fig. 13 shows the learning activities in the classroom. In these activities, students discuss the physical and mathematical meaning of a phenomenon or physics experiment. Frederico and Gianotto (2017) underlined that the use of dual coding theory in physics engaged students in positive learning experiences. Through physics laboratory, students apply this theory either in theoretical physics or laboratory practice. While in Fig. 14 is a physics experiment activity, laboratory activities that invite students to understand physics directly and strengthen the long-time memory stored in the brain. Because learning with laboratory activities or actual knowledge can be more easily remembered and stored in the right mind (Quas, Goodman, Bidrose, Pipe, & Craw, 1999).

4. Conclusion

The results of this study are that the physical laboratory conditions in Indonesia are relatively good, but the quantity of laboratory use is low. The topic of physics that often carries out laboratory activities is on mechanics. Besides, physics experiment and theoretical approach are inseparable things, like complementary currencies, as if they were separate, but they are one. Physics experiments are carried out in a laboratory or in nature, to find out the actual knowledge of physics directly, and the theoretical approach is needed to provide students with full understanding.

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