

HOT Lab–Based Practicum Guide for Pre-Service Physics Teachers

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Abstract. The purpose of this study is to develop HOT (Higher Order Thinking) Lab-based practicum guide that improves pre-service physics teachers' creative thinking skills. The research method used 3D-1I model (Define, Design, Develop and Implementation). The subjects of this study are 40 students of Physics Education Program UIN Sunan Gunung Djati Bandung. The results showed that the HOT Lab-based practicum guide has the characteristics which: 1) contain context-rich issues, 2) solve problem through practicum, 3) apply physics concepts, 4) require creative and critical thinking in solving problems, 6) have alternative answers that are not trivial, 7) present the result of problem-solving. The implementation of HOT Lab can improve the creative thinking skills of physics teachers on the concept of the electric circuit. The HOT lab has characteristics as mentioned before and when being implemented, it can improve students' creative thinking skill as it is developed based on problem-solving laboratory and creative problem-solving. It can be concluded that HOT Lab-based practicum guide has been successfully developed and when implemented can improve the creative thinking skills pre-service physics teachers'. Thus, HOT Lab can be used as an alternative in developing high-level thinking skills.

1. Introduction

Laboratory activities in science learning have four main hierarchy functions for learners, namely: conducting experiments, doing laboratory work, practicum, and organize science learning based on the characteristics of the concept [1]. Moreover, the learners' experience of how to study physics, is seen as a process, followed by the emergence of a scientific attitude can be obtained through practicum [1-5]. *National Research Council* [6] and other scientific literature studies [7, 8] emphasizes the importance of rethinking the role and practice of laboratory work in science teaching.

The purpose of the practicum activity is to provide students with an understanding of scientific knowledge and to reassure their understanding of the methods used in studying that knowledge [9]. Some experts have different views on laboratory activities, resulting in various methods or manuals of practice with a different focus of competencies developed. Cookbook laboratory describes and supports what students are learning, teaching experimental techniques, less training thinking skills [10]. Inquiry laboratory improves learning meaningful to students, students'



conceptual understanding, and students' understanding of the nature science [11]. Problem solving laboratory improves problem solving skills and reduces student misconceptions when practicum [12]. Contextual laboratory improves understanding of students' generic concepts and skills [13]. Conceptual laboratory to develop *insightful learning* [14].

Every college facing the 21st century has both internal and external opportunities and challenges [15]. Demands the implementation of National Qualifications Framework Indonesia (KKNI), the implementation of *the ASEAN Economic Community*, the purpose of science teaching, the demands of learning that emphasizes *higher order thinking*, research and expert opinions on the importance of *transferable skills* are trained and developed in the students and the importance of practical implementation, the idea emerged to innovate in practicum activities through the development of practical models. Instructions practicum in the process train and develop some *higher order thinking skills*, then given name or term *Laboratory Higher Order Thinking* (HOT Lab). How to develop HOT Lab-based practicum guide?

2. Methods

The method used in this research is to know the development of higher order thinking practice directive through the 3D-II model (Define, Design, Develop and Implementation). Stage Define is done through field study, interview and literature study to collect various practice manuals applied in various universities and has been developed by the experts and previous researchers. Design stage is done to design various activities in the HOT Lab manual. Develop stage is done to construct various activities and systematically in the stage of practice manual that has been made at the Design stage. HOT Lab was developed based on problem solving to train high-level thinking skills through practicum. Phase Implementation was conducted to test the use of HOT Lab which was developed in improving transferable skills especially the creative thinking skill of physics education program student at UIN Sunan Gunung Djati Bandung. Research subjects of 40 students in the fourth semester of the academic year 2016/2017. Improving students' creative thinking skills using the Hake formula and category [16].

3. Results and discussion

The development of HOT Lab on electric circuit concept is more emphasized on the development of laboratory problem solving by adding non-trivial answer alternatives in solving problems, limiting and requiring creative thinking skill and critical in solving problems through practicum and practicum result presented. Further development of HOT Lab will be discussed as follows:

3.1 Define

Stage analysis is the process of needs assessment, such as the stage to identify the problem of research (needs) and to perform the analysis of activity stages in doing the lab. The output of the analysis process is more emphasized on the development of problem-solving practice manuals that require high-level thinking skills. Based on further analysis, researchers have gained the development of HOT Lab. Interviews with heads of laboratories and lecturers, analyzes were conducted on various practical guidelines applied to Basic Physics courses in Physics Education Study Programs at several educational and teaching institutes (LPTK) in Indonesia (Universitas Pendidikan Indonesia, Universitas Negeri Jakarta, Universitas Negeri Malang, Sriwijaya University, Jambi University). Based on the results of interviews and analysis of laboratory manuals used in Basic Physics courses, obtained information of several LPTKs in Indonesia as a whole, apply the Basic Physics practicum which is integrated with Basic Physics courses, and some are separated. Practical instructions are used when laboratory Physics consists of the cookbook, guided inquiry and *problem-solving laboratory*. It shows *transferable skills* of student and teachers who have not been trained and developed at the lab Physics. Researchers made a fundamental revision of the existing practice manual. Practical guides have been developed based on real context problems encountered in everyday life and trained creative thinking skills and critical thinking through the HOT Lab. With the fundamental revision of the practice manual, the analysis process resulted in the development of HOT

Lab which is increasingly brewing and improving the transferable skills of the students, especially the creative thinking skills.

3.2 *Desain*

This step is known as making a blue-print, in which, making a design on paper first before creating a building. The design in question is a HOT Lab practice manual used in learning. The HOT Lab practice manual focuses on the systematic stages of activity in conducting the practicum especially in relation to electrical circuit concepts, through the description of real problems, circuit drawings, and graphic relationships among related physical magnitudes. The HOT lab manual is based on combining both the Creative Problem Solving (CPS) and Problem-Solving Laboratory (PSL) models consisting of five stages: 1) understanding the challenges, 2) producing ideas, 3) preparing for practicum activities, 4) carry out practicum activities, and 5) communicate and evaluate the results of activities. Stages are then decomposed into 11 activities that include: *real-world problems*; Determine and evaluate ideas; Experimental questions; Materials and equipment; Prediction; Question method; exploration; measurement; Analysis; conclusion, and presentations [17]

3.3 *Develop*

The development stage is the process of realizing a blueprint or design into reality. This means that every activity in the practice manual has been described clearly and systematically in order to be implemented by the students according to the intended purpose. As an example of activity in the HOT lab guide steps that have been prepared during the development stage shown in Figure 1-3.

Apakah dengan menambahkan baterai yang disusun secara seri dan menambahkan hambatan yang disusun secara paralel dapat memperbesar arus listrik yang mengalir pada rangkaian? Jelaskan.

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Figure 1. Example of activity on HOT lab experiment question

Gambar sketsa grafik tegangan terhadap arus listrik yang mengalir pada rangkaian sebelum dan sesudah ditambahkan beda potensial secara seri pada kedua ujung rangkaian dan hambatan secara paralel pada rangkaian.

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Figure 2. Example of activity on HOT Lab prediction

PERINGATAN: Kamu akan bekerja dengan *power supply* yang dapat menghasilkan tegangan listrik yang besar. Penggunaan yang tidak dibenarkan dapat menyebabkan luka bakar yang menyakitkan. Jangan pernah menggenggam kabel di ujung logam.

Gambarkan skema rangkaian alat untuk kegiatan eksperimen untuk mengecek kebenaran prediksimu.

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Figure 3. Example of activity on HOT Lab exploration

3.4 Implementation

Implementation is a concrete step to apply the practice manual that has been made. That is, at this stage all that has been developed is arranged in accordance with the role or function to be implemented. Once the product (laboratory manual) is ready to be applied, the test is then evaluated and revised to produce a ready-to-propagate finished product. However, the initial design of the HOT Lab guide was only conducted on experiments on electrical circuit topics and small group evaluation.

Students at the implementation stage do practicum about electrical circuit to solve real world problem as follows:

You and your group, when going fishing in the ocean stranded on a deserted empty island. To ask for help on the ships passing around the island you and your group have to turn on the signal *Save Our Souls* (SOS) from a special lamp. To turn on the lamp, it takes an electric current for that you and your fellow group try to make the electrical circuit as shown in Figure 4a.

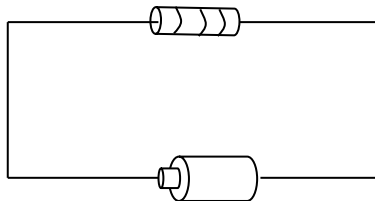


Fig 4a. Simple electric circuit

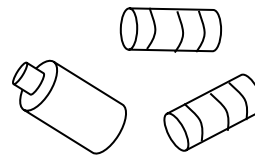


Fig 4b. Batteries and obstacles

Unfortunately, the electric current generated in the circuit is too small and not enough to light the lamp. It takes an electric current that is four times larger than that flowing in the circuit. If only there are three more that have a battery electromotive force (emf) which is the same value as that mounted on the circuit these needs will be fulfilled. Unfortunately, in the toolbox you carry there is only a battery and to buy it certainly not possible. In addition to a battery, in the toolbox there are two barriers whose resistance values are the same as those mounted on the circuit as shown in Figure 4b. Some of your colleagues gave an opinion to add the available components in the box to the circuit to produce the required electrical current. The opinions conveyed consist of:

- 1) According to Azka, in the circuit must be added the batteries in series and one in parallel barriers. The reason for obtaining an electric current that is four-fold in the circuit, then the potential difference which is measured at both ends of the enlarged circuit is one-fold and the resistance is reduced by half a fold.
- 2) Firman suggests that the circuit plus the right of the batteries in series and two barriers in parallel with the barriers that have been installed. The reason for obtaining an electric current that is four-fold in the circuit, then the potential difference which are measured at both ends of the enlarged circuit one-fold and the resistance is minimized by a third
- 3) Joko suggested that the series just added two barriers in parallel with the barriers that have been installed. The reason for obtaining an electric current is fourfold in the circuit, the resistance is minimized one-third times than before, while the battery does not need to be added any more reason not to enlarge the potential difference one-fold at both ends of the circuit.

You are confused by the many opinions your colleagues ask, which opinions to choose. To ascertain the opinion of who is most appropriate then your group conducts direct testing on all three-proposed series.

The idea chosen to solve the problem is Azka's idea because to obtain a current flowing in a quadruple circuit is to increase the potential difference flowing at both ends of the circuit, one-fold and minimize the block a half-fold. Adding one battery to the circuit means enlarging one potential difference in the circuit. Adding one obstacle to the circuit in parallel means minimizing the resistance

to the circuit. Both of these can enlarge the current flowing in the circuit. Thus, the current flowing in the required.

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Students conducting the implementation of a practical guide on the electrical circuit are 40 people divided into ten groups, each group consists of 4 people. Of the ten groups 6 groups chose Azka's opinion, 2 groups chose the opinion of Word and 2 groups of opinion Joko. Figure 5 is an example of HOT Lab implementation done by Physics Education Study Program UIN Sunan Gunung Djati Bandung.



Figure 5. The Implementation phase pf the HOT LAB

Overall average increase in N-gain creative thinking skill of physics teacher candidate after applied HOT Lab practice manual on electrical circuit concept is 0.54 including medium category. Table 1 shows the percentage of students in each category of creative thinking skills improvement.

Table 1. Percentage of the number of students in each category increase creative thinking skill

Increased Category of creating thinking skill	Nu of students	Percentage (%)
High	10	25
Medium	27	58
Low	7	17

The result of the research with HOT Lab practice manual showed improvement of students' creative thinking skill in high category by 25%, medium category 58% and low category 18%. The data reported that students' creative thinking skills improved. These results reinforce previous research that CPS as a basis for developing HOT Lab manuals can improve creative thinking skills [18, 19].

Developing HOT Lab's lab manual can improve creative thinking skills [18,19].

HOT Lab has already a development from problem solving laboratory, with characteristics include: 1) contains a context-rich issues, 2) problem solving is done through practicum, 3) Apply the concept of physics, 4) contains limitations in terms of problem solving, 5) require creative and critical thinking in solving problems, 6) the results of the problem solving should be presented [17].

4. Conclusion

In general, we have successfully developed the HOT Lab manual through the 3D-II model. The HOT Lab practice manual can improve students' creative thinking skills, so it can be applied to improve

other high-level thinking skills. The HOT Lab practice manuals can also be applied to other physics concepts and at other levels of education other than college.

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