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Unveil of Virtual Physics Laboratory (VPL) with Battery Microscopic Simulation (BMS) to Promote of Problem Solving Activity

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Abstract. Electricity concept is a concept that microscopic and difficult to see by eye directly (unobservable). Unique example of the concept of electrical energy is a battery. The movement of protons and electrons inside cannot be seen, but it still can produce energy. It causes the students to have difficulty in understanding the concept. The Virtual Laboratory designed to improve the understanding of the concept how the battery's working. This study was conducted by 102 physics teachers of senior high school in the experimental group in learning to use the Virtual Physics Laboratory (VPL) with Battery Microscopic Simulation (BMS). The results shows questionnaires data for indicators of carrying capacity from Laboratory by physics teachers and post-test effectiveness from VPL with BMS to promote of problem solving activity. This virtual laboratory designed to overcome conceptual mastery difficulties that can effectively assist students to promote of problem solving activity.

INTRODUCTION

The description of the learning achievement stated in the national standard of higher education suggests that every university is required to be able to equip students with various competencies in order to compete with the challenges of the 21st century. These competencies include open thinking skills, critical thinking skills, innovative thinking skills, problem solving skills, collaborate skills, and communication skills, as well as ICT literacy that is collectively known as 21st century skills. In order to realize these competencies, problem solving activity needs to be accelerated [11] and problem solving activities too [8] [17]. Problem solving laboratory is very important for students considering several reasons. The reasons are: (1) The effectiveness of higher education is being assessed to the extent which students obtain the skills they need to work in a problem solving-oriented laboratory [7]; (2) Colleges around the world are expected to graduates those who have skills in problem solving that able to respond change and complex needs in the workplace [1]; (3) Workplace' competitions are expected higher education institutions to instill problem solving skills from the curriculum [12]. In addition, problem solving also has a major contribution in building student' competencies with a number of considerations: (1) if able to develop problem solving skills, one can take decisions objectively and independently [13]; (2) Through problem solving, the ability to think of students becomes more skilled in selecting relevant information then analyzing it and finally re-examining the results;

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(3) Fostering the development of feelings of attitude (wanting to know more) and critical-analysis both individually and in groups.

The laboratory is an effective mode of learning to improve students' understanding and scientific process skills [7] [15]. There are four reasons to importance of laboratory activities, namely: (1) Laboratories can generate motivation to learn science; (2) The laboratory can develop basic skills in experimenting; (3) Laboratories as a vehicle for learning to apply scientific approaches; 4) The laboratory can support the mastery of learning material. The main purpose of the physics laboratory is to improve physics knowledge; develop practical skills; generate interest, develop creative thinking and problem-solving abilities; improve scientific thinking skills and provide training in experimental methods [13]. Laboratory activities also offer learning experiences that are rich in context, enhance conceptual understanding, develop practical skills [5] [6], and are the best way to reflect the nature of science [2]. Electricity concept is a concept that is microscopic and difficult to see by eye directly (unobservable). A Unique example of the concept of electrical energy in the battery, cannot see the movement of protons and electrons so that the battery can produce energy. A battery is a device that can store chemical energy and produce electricity when needed. Batteries are widely known in their use as energy sources for electronic goods such as toys, flashlights, and others. The advantages of batteries as a source of electrical energy are easy to carry. Electricity is produced by batteries that arise from the difference in electrical energy potential of the two electrodes. The difference in potential is known as cell potential or electromotive force [16]. To complete the reaction inside the battery, a charge transfer media and an external circuit are needed as an electric current.

Modern service systems are complex multi-factor systems that are distributed. To teach and learn how interactions, decisions and collaborations between various parties are managed when designing and implementing complex systems, and simulations for learning methods gain popularity [4] [6]. Some educational material related to virtual media has been developed in part by Physics at the University of Colorado PhET Simulation in a form that can be accessed and downloaded by the public for free. The battery concept is a microscopic concept of rotational dynamics that is very complex and is related to everyday life. One method that teachers can use to make it easier for students to understand the concept of battery material is a practical method. Laboratory activities can train students to become proficient in problem solving in accordance with physical theories learned in class. Presenting the problem above shows that there is a need to learn designs that fit the needs. Multimedia for learning with information technology as a basis can help improve learning independence and conceptual understanding. Multimedia learning refers to the combination of different audiovisual media that can be used in teaching and learning activities [4].

The recent decades, research have publicized that students move toward to science lessons by instructional conceptions and ideas concerning the phenomena and concepts to be academic that are not in harmony amid knowledge views. Besides, conceptions and ideas are firmly held and are resistant to change [11]. Over the past three decades, the term problem solving learning has been used in science education as a synonym for 'good and meaningful' learning of science. The statement that students must learn science by imitating the process of constructing knowledge in science is not new and has become a leading idea in the reform of science education since the 1950s. In science education, problem solving learning describes an approach in which students actively learn using scientific methods to answer research questions. However, the entire cycle of problem solving learning to ask research questions, collect data, and interpret results is not always used in science classes. In praxis, activity varies. In some cases, teachers provide research questions, data collection methods, and interpretations; in other cases, teachers leave responsibility for some or all components of problem solving learning to students. Define of four levels of problem solving learning based on the amount of guidance from teachers (Tab. 1) [14]. In verification (level 0) the teacher provides research questions, data collection methods, and guidance on how to interpret the data to answer research questions. Level 0 activities are traditional 'book-like' activities that provide recipes to answer research questions. In structured problem solving learning (level 1) students are provided with research questions and data collection methods but are not given guidance on how to interpret data. In guided problem solving learning (level 2) students are given research questions but no further guidance. In open problem solving learning (level 3), students choose data collection methods and interpret data to answer their own research questions without any guidance.

However, pay attention to batteries that require media to be able to see the movement of district power, which requires computer simulations designed to improve understanding of the working concepts of batteries. Because of the particle size, which is microscopy, the conceptual change that takes place can be a long experience. So that simulation is needed as a tool to visualize the concept microscopically through virtual simulation. The steps of developing virtual multimedia undertaken in this study include phase analysis, planning or design, production and evaluation [3]. One software program that can be used to make virtual simulations is Macromedia Flash 8.0. Several benefits by this simulation can combine text, animation, sound and color. Based on the description above, is the Virtual Laboratory problem formulation designed to increase understanding of the concept of microscopic battery simulation (BMS) promotion of problem solving activities?

METHOD

The purpose of the research is to unveil Virtual Physics Laboratory (VPL) with Battery Microscopic Simulation (BMS) to Promote of Problem solving Activity. Quantitative study design used is one-group pretest posttest design with a scheme according to [9]. Tests of understanding the concept of the experimental class applied using one group posttest only design as shown in Figure 1.

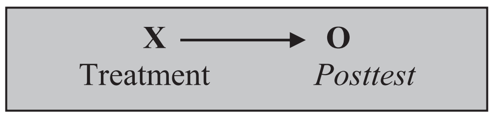

Figure 1. Design One Group Posttest Only

Information:
O: The Questionnaire understanding of physics of microscopic phenomena
X: Treatment in the form of Virtual Physics Laboratory with BMS for problem solving activity on experimental group.

A total of respondents 102 teacher physics of senior high school. The sample was randomly selected from second year student teachers undertaking an introductory physics course. A few parts of these students have already studied VPL in physics laboratory of senior high school in Banten, Indonesia.

RESULT AND DISCUSSION

Development Battery Microscopic Simulation (BMS)

Virtual simulation development stage that is done in this study included the analysis phase, the planning or design, production, and evaluation [15].

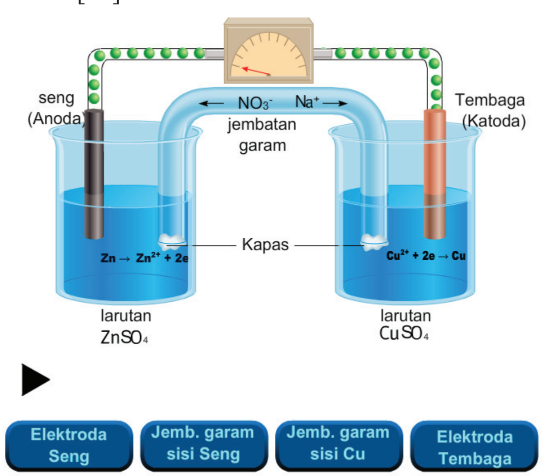

Figure 2. Result Development of Battery Microscopic Simulation (BMS)

Curriculum analysis has succeeded in choosing the expansion of solid terminology by considering material containing several abstract concepts, so that it is very accurate when creating interactive multimedia that can simulate events that are observed or students can simulate. The results showed that the use of virtual media can change the perceptions of students who have a conceptual understanding through deep restructuring concepts [4].

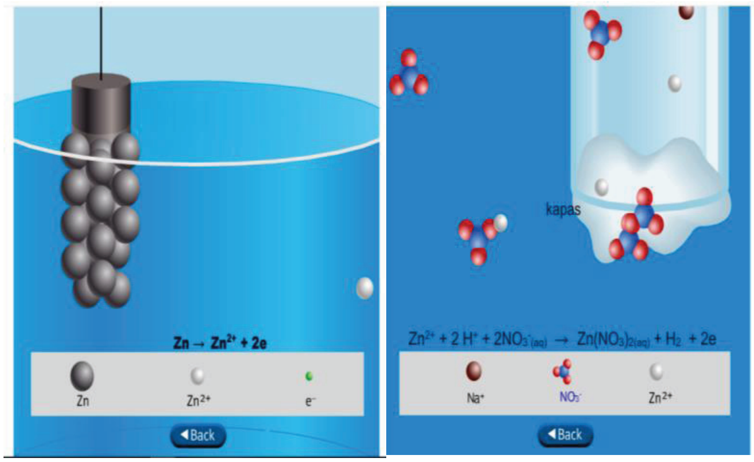

Figure 3. Reaction of Zn electrode and salt electrode bridge Zn for Battery Microscopic Simulation (BMS)

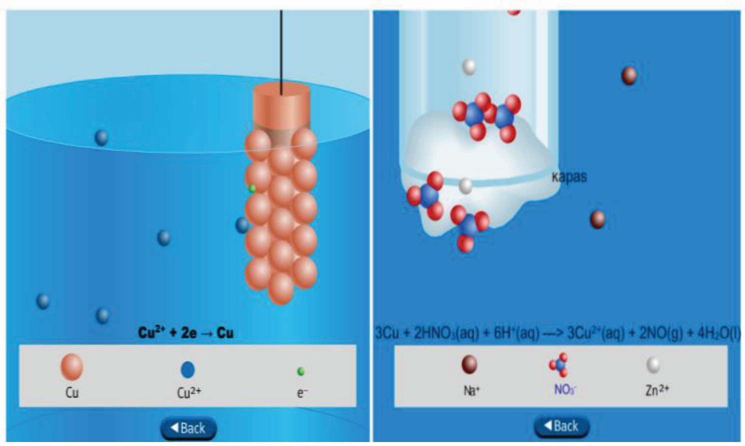

Figure 4. Reaction of Cu electrode and salt electrode bridge Cu for Battery Microscopic Simulation (BMS)

Based on Fig. 1. The information of Electro-Motive Force (EMF) can be generated by two different metals and separated by electrolyte solutions. Volta gets a copper (Cu) and zinc (Zn) metal pair which can generate a larger EMF than other metal pairs with reaction:

Anode : $Zn \rightarrow Zn^{2+} + 2e$

Cathode : $Cu^{2+} + 2e \rightarrow Cu$

Reaction : $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

Data of Need Assessment VPL

Data from the need assessment results in the form and feasibility of laboratory in high schools were obtained from the results of distributing questionnaires directly to high school physics teachers in West Java. The questionnaire is also distributed online with the address https://goo.gl/forms/D9gA2vJAgJsjesbA2. The number of respondents from the results of the questionnaire was 202 people. The indicators contained in the questionnaire are seven, namely: 1) Laboratory Carrying Capacity, 2) Laboratory Implementation. The categories for each indicator are converted in the form of percentages consisting of: Less (0% -33.3%), enough (33.4% - 66.7%), Good (66.8 %% - 100%).

The results of the questionnaire distribution for each indicator are presented as follows. Carrying Capacity of Laboratory Data from questionnaires for indicators of carrying capacity of laboratory are shown in Table 1. The power to support the laboratory in each school is considered sufficient.

Table 1. Practical Capability

No	Questionnaire	Total Ideal	Total*	%	% Total**	Category
1	My school has a physics laboratory room	204	156	76.5	55.4	Enough
2	Laboratory activities are guided by a laboratory book / module	204	175	85.8		
3	The physics laboratory at my school is supported by a laboratory	204	64	31.4		
4	The laboratory equipment that is owned is in accordance with standard requirements	204	87	42.6		
5	I have good knowledge and mastery of laboratory models	204	83	40.7		
	Total	1,020	565			

Note: * The number of respondents who answered "YES"
**% total = (Number of respondents who answered "YES" / Ideal Number) x 100%
= (565/1,020) x 100% = 55.4%

Based on Tab. 1. The information data from questionnaires for indicators of carrying capacity of practicum in sufficient categories. However, that the development of VPL is needed to support the achievement of learning that becomes the demands of 21 Century, namely literacy for learning with problem solving especially Battery.

Implementation of VPL

Data from questionnaires for indicators of laboratory implementation are shown in Tab. 2. The laboratory implementation in each school is considered sufficient. Additional information related to indicators of laboratory implementation was obtained information that teachers who stated that they did not do laboratory = 2 people (2.0%), practiced 1-4 times per semester = 102 people (83.3%) and practiced 5-8 times per semester = 30 people (14.7%).

Table 2. Practical Practices

No	Questionnaire items	Total Ideal	Total*	%	% Total**	Category
1	I held a laboratory or experiment to support learning	204	196	96.1	61.0	Enough
2	Every important concept or main concept that I teach is supported by practical activities	204	25	12.3		
3	I conducted a separate laboratory with theoretical learning	204	117	57.4		
4	I carry out laboratory integrated with theory learning	204	160	78.4		
	Total	816	498			

Data from questionnaire distribution for laboratory barriers indicators are shown in Tab. 2. Practical barriers faced by teachers in each school are greatest in terms of practical time limitations and the smallest obstacles in terms of student motivation to conduct low laboratory.

Based on the data, the information obtained that students build understanding of phenomena and concepts that are reasonable and coherent seen through seeing through their own eyes that are not in harmony with the views that are universally accepted by the scientific community [14]. Media simulation is effective in helping students build their perceptions so that their ability to understand can be improved [13]. Using virtual simulation media for concepts enhances students' understanding of the concept of problem solving processes towards scientific concepts. Learning physics simulations using electric magnetic media can transform non-scientific students' perceptions into scientific views.

CONCLUSION

The implications of using a Virtual Physics Laboratory (VPL) designed to overcome conceptual mastery difficulties can effectively assist students in facilitating promote of problem solving activity. The results suggested that incorporation of learning by BMS for problem solving activity with VPL. The information data from questionnaires for indicators of carrying capacity of practicum in sufficient categories. However, that the development of VPL is needed to support the achievement of learning that becomes the demands of 21st century, namely literacy for learning with problem solving especially battery. Based on results of this study, it shows that students working with virtual simulation exhibited significantly higher score. Our findings strongly support that BMS can be used as an alternative instructional tool, in order to help students develop an understanding of physics concepts. The recommendation for further research are needed to develop and add material that may be made to simulate and complement the multimedia of virtual laboratories.

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