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The Development of Virtual Laboratory Using ICT for Physics in Senior High School

M Masril¹, H Hidayati¹, Y Darvina¹

¹Department of Physics, Faculty of Mathematics and Sciences, Universitas Negeri Padang, Padang 25131, Indonesia

masril_qch@yahoo.com

Abstract. One of the problems found in the implementation of the curriculum in 2013 is not all competency skills can be performed well. Therefore, to overcome these problems, virtual laboratory designed to improve the mastery of concepts of physics. One of the design objectives virtual laboratories is to improve the quality of education and learning in physics in high school. The method used in this study is a research method development four D model with the definition phase, design phase, development phase, and dissemination phase. Research has reached the stage of development and has been tested valid specialist. The instrument used in the research is a questionnaire consisting of: 1) the material substance; 2) The display of visual communication; 3) instructional design; 4) the use of software; and 5) Linguistic. The research results is validity in general has been a very good category (85.6), so that the design of virtual labs designed can already be used in high school.

1. Introduction

In studying physics there are two inseparable aspects, namely physics as a product (knowledge of physics that consist of facts, concepts, principles, laws, and theories) and physics as a process (scientific activity). Therefore, physics learning must consider the characteristics of physics as a process and product [1].

To study physics as a process and product, it is necessary for inviting students to learn actively, not only acquire certain knowledge or concepts but directly involved in the discovery of the concepts. One of learning approach that can be used is science process skills approach.

Science process skills can be developed by practicum method. Through practicum activities, students not only get information of facts or concepts, but also learn to find them using various aspects of the science process skills, such as formulating problems, predicting, planning experiments, observing, using tools and materials, interpreting data (interpretation), applying concepts (applications) and communicating.

Based on the characteristics of physics as a process and product, the government through the Minister of Education and Culture has made a syllabus for physics in senior high school using the latest curriculum. It can be read with Regulation of Education and Culture Minister No. 59 in 2013. The fourth of main competence describes the importance of practicum activities. Thus, schools should facilitate laboratory to do a practicum.

Based on the results of observations in senior high schools of Padang, most schools do not have complete laboratory facilities to support the implementation of the latest curriculum so many

practicum projects that cannot be practiced. Based on the experience of researchers when doing research in 2015 for teaching materials, it was found some weaknesses of learning in school, such as practicum activities could not be done although the student worksheet has been designed to help physics learning.

Theoretically, the process of learning in the classroom or in the laboratory includes in developing three competencies namely cognitive, affective and psychomotor. It requires balancing those competencies between theory and practicum activities. So, the laboratory is needed. The activities in the classroom can only assess cognitive competence while the implementation of the practicum may include assessment in students' affective and psychomotor competence. Activities in the classroom and in the laboratory in the learning process are inseparable because they are related to each other to achieve the objectives in the learning.

To solve the problem, the role of teachers is needed, because the teacher is the agent of change. Therefore, it takes various strategies and learning innovation to overcome the inadequacy of laboratory facilities and infrastructure without having to abandon the achievement of cognitive, affective and psychomotor competence.

Practicum activities can be done in various ways, such as the utilization of Information and Communication Technology (ICT), which is supported by the use of computers as an ICT device for example virtual lab experiments (virtual lab). Although the virtual lab is not a real activity, students can do a practicum like a real practicum. Virtual laboratory (virtual lab) is one of ICT-based learning process that can be used as an alternative solution for learning with practice method.

With the existence of virtual laboratory, students can understand the physics concept and teachers can design of physics lab for all concepts in physics. Virtual laboratory also minimizes the cost of procuring tools and practicum materials. They are many benefits of virtual laboratory such as 1) reducing time constraints, if there is not enough time to teach all learners in the laboratory until they understand; 2) Reducing geographic barriers, if there are learners whose location is far from the school; 3) Being economical, does not require laboratory buildings, tools and materials as in conventional laboratories; 4) Improving the quality of the experiment, as it is possible to repeat it to clarify doubts in laboratory measurements; 5) Increasing the effectiveness of learning, because learners will spend more time to practice repeatedly; and 6) Improving safety and security, as it does not interact with real tools and materials [2].

Virtual laboratory (virtual lab) is one of ICT-based learning process that can be used as an alternative solution for learning with practice method. Learning-based virtual lab is one of the superior products of advances in information technology and laboratories. According to Russel et al. [3], in teaching and learning activities, teachers should help learners develop their understanding by providing: direction and organization for learning, motivation of learning, conceptual explanations, activities that can help learners recognize and fix misconceptions, and opportunities to provide direction in problem solving. Visualization of the phenomena of physics and its concepts related to animation at the microscopic level, as well as the simulations associated with the daily examples of learners can increase the learner's knowledge visually and stimulate more learners to achieve a high level of understanding of the concepts in physics [3]. Based on the results of research, learners are more motivated to learn the concept of physics when accompanied by visualization abstract concepts [4]. The ideal virtual lab is run on the internet, so participants can experiment from wherever and whenever. However, it can also be run in an intranet environment or standalone computer. With virtual labs, the building and physical lab tools are transformed into computers and virtual lab software [5]. Based on what has been described, it has become clear that virtual labs can be used as an alternative to assisting human beings in improving human productivity and well being, solving problems, predicting how options of completing and implementing solutions.

Virtual labs are widely developed, as developed by the University of Colorado, Physics Education Technology (PhET) [6]. In PhET there is a theory and experimental simulation involving the user actively. Users can manipulate activities related to experiments, so that in addition to building concepts, PhET can also be used to bring up the skills of the science process.

Therefore, in order to implement the 2013 curriculum in high school and to meet the demands of the curriculum, the authors are interested in designing virtual labs through ICT for senior high school physics.

2. Research Method

The research method is a Research and Development (R & D) with the 4-D model. According to Thiagarajan et al.[7], the stages of development research are defined, design, develop, and disseminate.

2.1 Define

At this stage, the curriculum is analyzed by analyzing the main competence in physics syllabus and listing the practicum will be done in learning activities. This analysis needs to be done in order to design the lab with a virtual lab in accordance with the curriculum demands. Teachers have done a practicum in the learning process, but it is still in limitations because the laboratory is not so optimal. Therefore, virtual laboratories developed through ICT can help students practice finding concepts in physics learning both in the classroom and outside the classroom.

2.2 Design

In this stage, the virtual lab model is designed. This model is arranged in the order of main competence in the syllabus. Each practicum activity is completed with student worksheet, all integrated with ICT. The virtual lab model is systematically designed and interesting in order to achieve the expected competencies and objectives.

2.3 Development

In this stage, the virtual lab model is validated and revised based on evaluator and practitioner (user) suggestion, and limited trial. Then a second analysis and revision was performed based on a limited trial analysis. Valid virtual labs will be tested in the form of limited tests in sample schools. In the implementation of limited tests, it uses learning tools such as lesson plans and student worksheet. To find out the effectiveness, it can be analyzed from student learning outcomes. During the first year, it was a valid, practical and effective for learning in school.

2.4 Disseminate

The second year of research is the dissemination of products in senior high school students in Padang City. The sample school is chosen by stratified sampled. The dissemination was done in the form of quasi-experimental research in sample schools. The virtual lab is re-revised until it is ready for widespread use.

The product is tested again by five people to get validity value. The instrument used for the validity test is using a questionnaire consisting of five indicators: content feasibility, language usage, presentation, graffiti, and developed virtual lab products. Technique Data analysis conducted using qualitative analysis using graph..

3. Result and Discussion

3.1 Result

3.1.1 Validity: Feasibility

The results of virtual laboratory validation for the content feasibility indicator are obtained from the value of each indicator consisting of 8 statements, namely: 1) the suitability of the material with Core Competencies and Basic Competencies; 2) Compliance with students' needs; 3) conformity with the needs of virtual laboratories; 4) the truth of material substance; 5) material conformity with daily life; 6) benefits for the addition of knowledge insight; 7) conformity of training and evaluation with material; 8) conformity with values, morality, social. The results obtained from each Feasibility indicator statement are plotted in Figure 1.

3.1.2 Validity: Language Usage

The results of the virtual lab validation for language usage indicators are derived from the value of each indicator consisting of 12 statements namely 1) legibility, 2) idea density, 3) the beauty of the language style, 4) the use of the short length of the sentence, 5) the way of constructing a sentence, 6) how to write paragraphs, 7) the use of punctuation, 8) how to write physics terms, 9) how to write physics equations, 10) how to write table and picture titles, 11) clarity of information, and 12) the use of language effectively and efficiently. The results obtained from each indicator of language usage are plotted in Figure 2.

3.1.3 Validity: Presentation

The results of the Virtual Laboratory validation for the presentation indicator are obtained from the value of each indicator consisting of 5 statements, namely: 1) Clarity of purpose; 2) Order of presentation; 3) Provision of motivation; 4) Interactivity (stimulus and response); and 5) Completeness of information. The results obtained from each statement indicator of the presentation of Virtual Laboratory are plotted in Figure 3.

3.1.4 Validity: Graphics

The results of the Virtual Laboratory validation for the graphics indicator are obtained from the value of each indicator consisting of 5 statements: 1) the use of font (type and size); 2) layout, 3) illustrations, graphics, pictures, photographs; and 4) display design. The results obtained from each statement of virtual lab indicator are plotted in Figure 4.

3.1.5 Validity: Development Steps

The results of validation of Virtual Laboratory for the indicator of Virtual Labor developed are obtained from the value of each indicator consisting of 8 statements namely: 1) Design; 2) Linkage to concepts; 3) Ease of access; 4) Interactive; 5) A developed guide; 6) Material depth; 7) Meet all KD; 8) Evaluation in the form of adequate quiz. The results obtained from each of the Virtual Laboratory indicator statements developed are plotted in Figure 5.

3.1.6 Practicality: Ease of Use

The result of Virtual Laboratory practicality test for the Ease of Use indicator is obtained from the value of each indicator consisting of 5 statements, namely: 1) easy to operate; 2) can be used anytime; according to the needs of teachers; 3) easy to carry, because it can be accessed anywhere; and 4) can be used repeatedly; and 5) easy to interpret by the teacher in using interactive multimedia. Results obtained from each indicator statement Ease of Use of Student Worksheet developed with an average value of 85.94 in plotted in Figure 6.

3.1.7 Practicality: Attractiveness

The result of Virtual Laboratory practicality test for the attractiveness indicator is obtained from the value of each indicator statement consisting of 6 statements, namely: 1) Presentation of Student Worksheet based on attractive virtual laboratory; 2) The brief information in the Student Worksheet based on the virtual laboratory is equipped with an appropriate image of the material; 3) The pictures presented in the Student Worksheet are quite clear; 4) Display of Student Worksheet through interesting ICT; 5) The font type Student Worksheet read clearly; and 6) The combination of colors used is proportional. The results obtained from each indicator statement of the Student Worksheet developed with an average grade of 89.84 are plotted in Figure 7.

3.1.8 Practicality: Benefits for Teacher

The result of practicality test for the utilization indicator of Student Worksheet is obtained from the value of each indicator consisting of 4 statements, namely: 1) can be a reference for the teacher to activate the student in learning; 2) can support teacher's activities in fulfilling K13's demands; 3) can be used to motivate student learning; and 4) can make learning more interesting. The results obtained from each indicator with an average value of 89.45 are plotted in Figure 8.

3.1.9 Practicality: Opportunities for Implementation

The result of practicality test for LSM Implementation indicator based on virtual laboratory is obtained from the value of each indicator consisting of 5 statements, namely: 1) facilitates students to work in accordance with scientific method; 2) help students to think critically; 3) makes learning time more efficient; 4) can help students learn independently; and 5) Evaluations can be used to measure students' mastery of learning materials. The results obtained from each statement indicator of Student Worksheet implementation opportunities developed with an average value of 83.13 are plotted in Figure 9.

3.1.10 Average Value for Practicality

The results of the virtual laboratory practice test are obtained from the mean values for each indicator. The average results of validity values for each indicator are: Ease of use (85.94), attractiveness (89.84), Benefit (89.45), and implementation opportunities (83.13), so the average value of the test results of practice virtual lab with four indicators is 87.09. Based on these values it can be argued that all the virtual lab indicators are in very high categories.

3.2 Discussion

From the validity test, virtual lab can be explained as follows: The virtual lab has shown the suitability of the material with the basic competencies. The virtual lab is very useful in practicum. The content is described in good explanation so students can prove the concepts. In addition, the steps to learn virtual labs are made as detailed as possible so as to make it easier for students to use the developed virtual lab.

In general, virtual lab is understandable because of the language. This is due to the density of ideas in developing sentences, how to construct sentences, how to construct paragraphs, how to write table titles and drawings, and the use of language effectively and efficiently in accordance with the enhanced spelling. Besides, the high value of validity is caused in the development of virtual lab many express new ideas that make it easier for students to learn the virtual lab developed. .

Virtual lab provides motivation and interactivity (stimulus and respond). Theoretically, giving motivation can improve the activity of the child. In addition, the presentation of virtual labs equipped with animations that appeal to students can also increase students' interest to learn so that students are interested to learn it. The presentation of virtual lab makes it easier for students to study anywhere and anytime.

Virtual lab uses varied fonts, layout and neat layouts, interesting picture illustrations and good display design. Besides, the illustration of the picture is interesting and complete with a complete description. Virtual lab is in high category because the value of each statement of the developed indicators has been high such as: design, linkage to the concept, Ease of access, Interactive, easy-to-understand guide, material depth, and Evaluation in the form of quiz interactive.

Based on the results of practical tests, virtual lab are: easy to operate, can be used anytime in accordance with the needs of teachers, easy to carry because it can be accessed anywhere, can be used repetitive, and easy to interpret by the teacher in using interactive multimedia.

The presentation of worksheet based on the virtual laboratory is interesting, the short information in the worksheet is equipped with the appropriate picture, the pictures are quite clear, font type clearly reads , the color combination used is proportional. It can be a reference for teachers in enabling students in learning; can support teacher activities in meeting the demands of Curriculum, can be used to motivate student learning; and can make learning more interesting. Virtual lab facilitate students to work in accordance with scientific method, helping students to think critically; making learning time more efficient; help students learn independently; and can be used to measure students' mastery of learning materials.

4. Conclusion

Based on the results of research and discussion that has been done can be concluded: First, The results of virtual lab validity test included high category with validation value 85.6 while practical test 87,09. Second, Virtual lab designed this can be used for physics learning of the latest curriculum in high school.

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