Advanced Virtual Physics Laboratory (VPL) of Dynamic Electricity

Firmanul Catur Wibowo, Agus Setiawan, Ni Ketut Rahayu, Dina Rahmi Darman, Agus Setyo Budi

Abstract: The ICT for education has become the guiding principle of physics education in many countries and is the focus of research efforts. The development of physics education focuses on the use of technology as a means to integrate many subjects. The focus on new technologies and practical applications is to develop a website-based Virtual Physics Laboratory (VPL) of electricity concept for integration knowledge to effectively solve problems. The method used in this study is Research and Development (R & D). The instrument of this research is the team feasibility questionnaire expert and student response questionnaire. The Research was conducted on 60 students, whose age ranging from 18 to 20. Research result shows that based on the assessment of content experts an average 84.44 % and media experts VPL has very decent criteria with an average of 87.50 % and has very criteria both in response to students with an average of 86 % with category very good. The level of student acceptance of the main learning in the VPL model also shows that students tend to accept the use of Relevance, Confidence, and Satisfaction from virtual experiments.

Keywords: Virtual Physics Laboratory, Dynamic Electricity.

1 INTRODUCTION

Physics is part of the natural sciences which contain science nature which is expected to be a reference for students in learning about themselves and the environment. Learning physics emphasizes provide direct experience to develop abilities competency of students to be able to explore and know nature universe scientifically [1]. Constructive learning of science as a process for building dynamic, organizing, and providing more explanation further in the knowledge they get [2]. The results of preliminary observations conducted by researchers at several publication of virtual physics laboratory, the researchers found that learning physics, especially material electricity in schools in applying practicum-based learning there are several obstacles such as lack of facilities and infrastructure implementation of the practicum and the changes in the times increasingly dynamic that has an impact on the world of education [3]. Problem Practicum implementation in schools has many obstacles, including expensive laboratory equipment, incomplete equipment laboratory in school, time constraints in carrying out lab work and the difficulty of doing abstract and microscopic laboratory work [4]. Good physics learning is one of application practicum based learning model [5]. The practicum based learning can be used as an alternative learning that can encourage students to actively learn to reconstruct conceptual understanding. Teachers and schools of generally only have limited access to resources so that they cannot provide tools practicum, replace damaged lab equipment, and provide adequate laboratory space [6]. The researcher found that to procure this practical equipment big fees are needed. Therefore it is necessary to find alternative solutions with costs that are relatively cheaper, practical, and efficient.

- *Firmanul Catur Wibowo, Agus Setiawan, Ni Ketut Rahayu, Dina Rahmi Darman, Agus Setyo Budi*
- *1, 3, 4 Department of Physics Education, Universitas Sultan Ageng Tirtayasa, Indonesia (firmanulcaturwibowo@untira.ac.id)*
- *2Department of Mechanical Engineer Education, Universitas Pendidikan Indonesian, Indonesia (agus_setiawan@upi.edu)*
- *5Department of Physics, Universitas Negeri Jakarta, Indonesia (agussb@unj.ac.id)*

Virtual laboratory (VL) is one alternative that can used to overcome these problems, where we can do practicum using a computer or laptop media in it already available features needed for practicum [7]. VL can provide practical experience resembling physical practicum activities in general. In addition, costs making virtual laboratories is relatively cheaper when compared to procurement of physical laboratories. This is possible because of the laboratory virtual does not require extensive space, minimal equipment replacement costs damaged lab, and efficient because it does not take long to preparing practicum tools [7]. The selection of the topic of dynamic electricity is due to this topic is one of the physics topics that must be done in even semester in which contains practical activities. Practicum with concept electricity costs a lot because the price of the equipment is expensive, in addition, practicum equipment is also susceptible to damage. Damage this can be caused by many things, such as the treatment of non-practitioners according to procedure, etc. Besides having low initial procurement costs, one of the advantages of virtual laboratories compared to physical laboratories is the lack of maintenance costs because all practicum tools are of a nature virtual. The some disadvantages of conventional laboratory work systems, namely, a lot of time is spent by students in preparation for activities laboratories such as preparing tools and inspection of equipment by supervisors, measuring instruments must be protected from accidental damage, reports practicum containing analysis of measurements prepared by students after leaving the laboratory so there is no possibility for measurement checks or repetitions that can support deeper understanding of the subject, and the existence of work groups at the laboratory produces ineffective engagement for all students during the laboratory [8]. Third, based on a data list of practicum tools Physics laboratory, the number of sets of ohm law practicum tools is very limited that is, only four sets of practical equipment. Even though this simulation is not one hundred percent can replace the real experiment, but in terms of learning is sufficient, even easier to understand because interesting and educative. The students who learn by using VL are more interactive than traditional classes and Physics learning achievements in traditional classes are slightly higher compared with virtual laboratory classes. VL can support practical activities in laboratories that are interactive, dynamic, animation and virtual environment so it's not boring, and can support the user's desire to understand the subject matter.

Based on the description above, the researcher feels the need to do so website-based virtual laboratory development that can be used in the process of physics learning activities [10]. VL are an interactive experience where students observe and manipulate system objects that are generated, data, or phenomenon in order to fulfill learning objectives [11]. VL can be defined as a learning environment simulate a real laboratory. Who provides tools, materials, and other lab infrastructure for students on a computer intended to do experiments either by individuals or per group at any time and wherever this Experiment is stored in Compact Disk (CD) pieces or on website [12]. One of the virtual studies laboratory in the field of physics engineering, as many as 93% of respondents assume the virtual laboratory has many uses. One of its uses is acceptable by all users because it can provide knowledge for students, teachers and other people who want to develop their knowledge VL [13]. The use of virtual laboratories e.g. (a) can be used anytime and anywhere, (b) inviting students to have deeper opportunities doing experiments especially in limited time, complexity experiment and accident risk, (c) increase student learning enthusiasm through interactivity, (d) increasing the ability to use IT, (e) linking and strengthening the theory acquired in class, (f) more effective in terms of costs especially experiments with high error rates, and (g) able to provide feedback [14]. VL is an interesting learning media and fun because it displays images, animations, and interactive simulations so that it can improve understanding of concepts and motivation to learn. However, need of media for learning innovation product computers and technology can be applied in schools with technology information in the learning process. VL are cheaper, safer and suitable for use by students who have a visual learning style because of students can explore VL according to speed and needs. It is necessary to design a media development for get a product in the form of a virtual laboratory on the concept of dynamic electricity. VL which researchers will develop on a website-based basis this virtual laboratory can be accessed wherever and whenever, it contains program that provides a set of tools and materials, then users can do experiments or experiments according to instructions and then can develop other experiments based on these instructions. This virtual laboratory is expected to be the solution to the problem schools that do not yet have complete laboratory equipment. Therefore researchers will conduct development research under the title "Virtual Development Website-based Physics Laboratory in Dynamic Electricity

2 Research Methodology

The research is a research and development (R & D) that is oriented towards product development. In this study the product developed was in the form of Virtual Physics Laboratory (VPL) media on the concept of ohm law. The design of this study refers to several stages of the development research model. The development research model used is a 4-D model developed [14]. The 4-D development model consists of four main stages, namely: Define, Design, Develop and Disseminate. But in this study only carried out until the Development stage, namely limited Test to students to find out students' responses to the media that have been developed. This development research was carried out in the 2018/2019 academic year, namely in the odd semester. The location of this research is in one of the teacher colleges in Banten Province, Indonesia. The subjects of the Test in the media development research Virtual Physics Laboratory (VPL) on the concept of ohm law were students of 5 semesters of 60 students, whose age ranging from 18 to 20. This stage was carried out to determine the students' responses to the VPL media developed. The object of this research is virtual lab-based learning media on the concept of ohm law which can visualize macroscopic and microscopic phenomena. The instruments used to collect data in this study are Questionnaires compiled include three types according to the role and position of the respondents in this development research. The research instrument was in the form of a questionnaire compiled based on the grid that had been developed and arranged using a questionnaire scale.

3 Result

3.1 Development of Media VPL

The third stage in developing this virtual laboratory is the stage of media development. The first thing to do at this stage is to make a scheme (flowchart) which is used as a navigation channel on the media developed, Gathering supporting materials such as clip art images, animations, images, sounds, etc. that are used to create media, create storyboards that used to make the correct frames, and produce materials through computers using HTML, CSS and JavaScript, but some other software is also used during the media creation process, namely: Mozilla Firefox or Chrome and Inks cape. The preparation of storyboards is intended to explain more fully about the media programs developed. Storyboards are presented in the form of tables with several components, namely numbers, page names, descriptions, media, buttons, display and learning indicators. The virtual laboratory that is developed includes the home page, basic theory page, pretest page, simulation page, login page and guide page. The home page in this virtual laboratory consists of welcome greetings, virtual laboratory names, practicum module titles, side bars, navigation bars that can appear in all of these virtual laboratory pages, and practicum purposes. This initial view is complemented by animated atomic movements to attract students' attention to the learning media developed as shown in Figure 1.

Figure 1. *The initial appearance of the virtual physics laboratory*

The next view is the basic theory page, in the basic theory there is a summary of ohm law material that is displayed in the form of Portable Document Format (PDF). On this page also provides features such as Rotate Clockwise to play PDF clockwise, download features for storing PDFs, print features for printing PDFs, and bookmarking features to make it easier for users to search for basic theory pages.

Figure 2. *Page views of the basic theory of the virtual physics laboratory*

The next appearance is the pretest page is the part that displays the pretest procedure and some questions about the pretest. In addition there is a send answer button that aims to save the answer and change the answer to a PDF file and the back button to the home page.

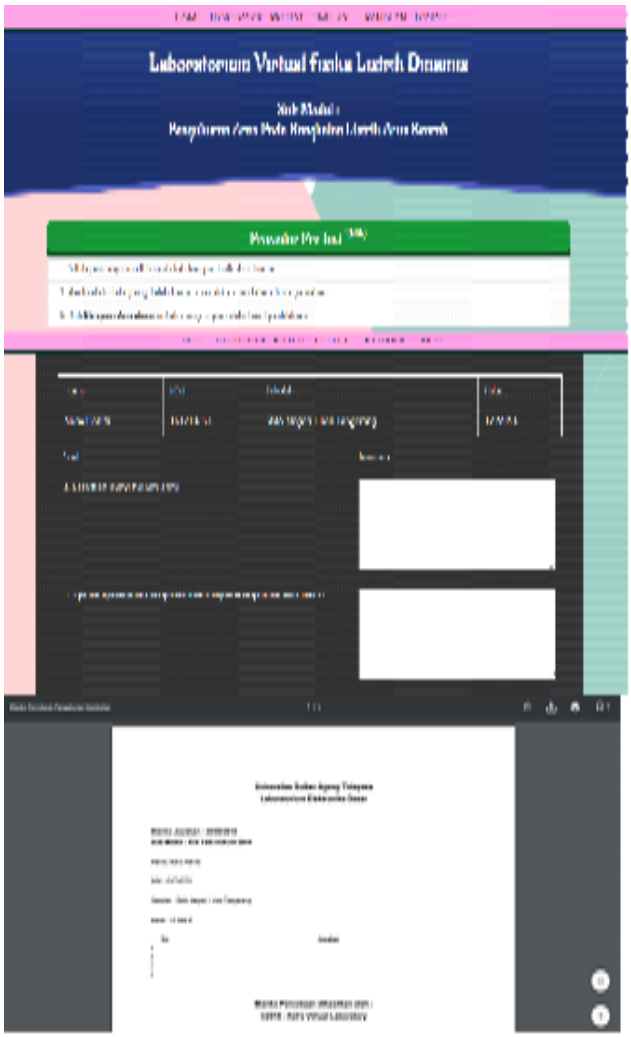

Figure 3. *Display page of the pretest virtual physics laboratory*

The next display found in this virtual laboratory is the simulation page. The simulation page is a page that displays lab simulations. Practicum carried out in this virtual laboratory is the measurement of barriers, current measurements and voltage measurements. On the practicum simulation page displays the practicum title, practicum procedure, and practicum time adjusted to practicum difficulty level, illustration drawing of practicum instrument which is made as closely as possible with practicum instruments in conventional laboratories, experimental blanks and stopwatches which function to remind practitioners about the time they use. The trial form serves to record the results of lab work consisting of the names of the practitioner, the Student Number (NIS), the school student, the student class, the data taken by the practitioner, the save button and the back button on the homepage. Just as on the pretest page, the save answer button aims to store lab data and convert the data into a PDF file.

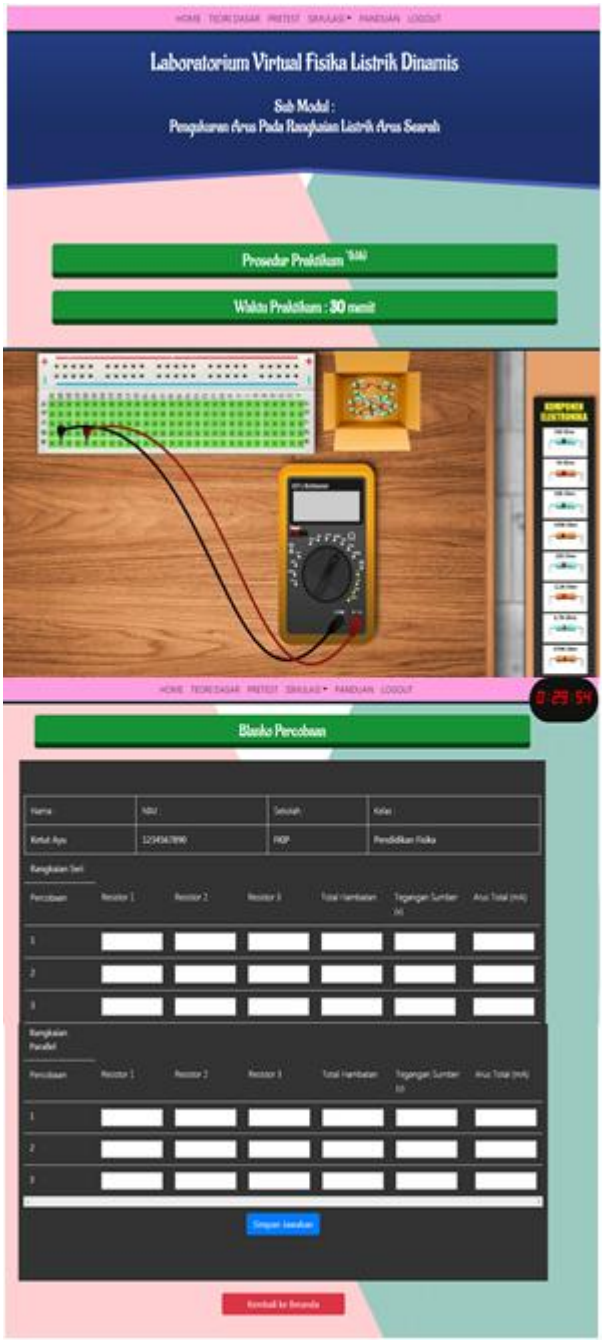

Figure 4. *Display page of practical simulation of virtual physics laboratory*

3.2 Product Evaluation of VPL of Content experts and media experts

Products that have been made are then consulted to be validated by media experts and physics material. This assessment aims to obtain input, suggestions, opinions, and evaluations of the media that have been made. Validation also aims to determine the feasibility of the media that has been produced, then tested on students to get the expected media development. In this validation stage there are 4 validators consisting of 2 lecturers and 1 computer teacher as media experts and 1 lecturer as a material expert. The results of expert media research can be seen in each of the results of the validation recapitulation. In general, the results of the validation of aspects of media substance by media expert validators are some notes and suggestions that are used to improve the media. From the overall validation that has been done by material experts and media experts, the results show that the VPL media that has been developed by researchers on average is very feasible with some improvements that must be made to improve the media. The results of media validation and material are shown in Table 1 and Table 2.

TABLE 1.
RESULTS OF VPL SIMULATION EVALUATION MEDIA EXPERTS

No	Evaluation Aspect	Rating Score		
Virtual Laboratory Media Simulation Interactivity				
1	Ease of use of the navigation buttons	4	3	4
2	Clarity of the link button in another page	4	3	4
3	Ease of material structure to be understood	3	3	4
4	The use of language is simple and clear	4	2	4
Total		15	11	16
Average (percentage)		14 (87,50%)		
Category		Very Good		

Based on Tables 1, the information is obtained that the VPL media that has been developed is in accordance with the material of ohm law and with the appearance and interactivity of simulations that are already quite good. The media can already be used in research after improvements are made based on suggestions from experts, so that the media is truly suitable for use in physics learning, especially in ohm law concept. Based on Table 2, information is obtained that the virtual physics laboratory that has been developed is in accordance with the ohm law material and with the feasibility and simulation language that is feasible. Simulation can be used in research after improvement.

TABLE 2.
RESULTS OF VPL SIMULATION VALIDATION CONTENT EXPERT

No	Evaluation Aspect	Rating Score		
		I	II	III
Motivational Aspects of Learning:				
1	Simulation can develop logical thinking in understanding the concept of ohm law	4	4	5
2	Simulation can motivate	4	4	4
Total		8	8	9
Average (percentage)		8,33 (83,33)		
Category		Very Good		
Language aspects				
1	The language used	4	5	4
2	Complete sentence / information needed by the user	3	4	5
3	Use of words according to Enhanced Spelling	4	5	4
Total		11	14	13
Average (percentage)		12 (84,44%)		
Category		Very Good		

3.3 STUDENT RESPONSE TO THE MEDIA VPL

VPL media that has been validated by the expert team and revised based on the comments and suggestions of the expert team, then conducted a limited Test to students with a sample of 30 students. This Test was conducted to determine students' responses to media that have been made from aspects of media and concept. The following is the result of evaluating student responses to VPL media.

TABLE 3.
AVERAGE RESULTS OF ASSESSMENT OF STUDENT RESPONSE TO VPL MEDIA IN LIMITED TEST

No	Statement	Rating Result	
		Average	Criteria
1	I feel Learning using simulation is a new learning that is carried out at our institution	86,8	Very Good
2	I feel that VPL is used to facilitate me to understand physics concepts that are not visible to the eye	80,6	Good
3	I feel that VPL which is used in physics learning further increases my motivation to learn material changes in matter.	86	Very Good
4	I feel that VPL used in learning is interesting and easy to understand	87,6	Very Good
5	I feel SV-FM in physics learning can help me understand the concept	77,2	Good
6	I feel VPL in learning physics can help me understand microscopic concepts of physics2	82,6	Very Good
7	I feel that VPL that is used can make it easier for me to study physics	86,8	Very Good
8	I feel happy to learn using VPL and hope that it can be used on other subjects	86,6	Very Good
Score NP (%)		86%	
Category		Very Good	

Based on Table 3. information is obtained that the virtual physics laboratory that has been developed is in accordance with the ohm law concept and with the feasibility and simulation language that is feasible. Simulation can be used in research after improvement.

4 CONCLUSION

The conclusion of research is assessment of content experts and media experts, virtual simulation media laboratory has very decent criteria with an average of 87 % and has very criteria both in response to students with an average of 84 % with feasibility is category very good. The level of student acceptance of the main learning in the VPL model also shows that students tend to accept the use of Relevance, Confidence, and Satisfaction from virtual experiments. The recommendation of research the simulation of virtual physics laboratory developed in this study is still limited to one subject matter, namely ohm law, so that it is not possible for other researchers to develop this virtual laboratory simulation with other subject matter. The virtual physics laboratory simulation developed in this study is still limited to two-dimensional animation, so it is not possible for other researchers to develop this virtual laboratory simulation with three-dimensional animation.

5 Acknowledgments

The research was funded by research grant research at the Ministry of Research, Technology and Higher Education 2019.

REFERENCES

[1] Suryawati, E., & Osman, K. (2018). Contextual Learning: Innovative Approach towards the Development of Students' Scientific Attitude and Natural Science Performance. Eurasia Journal of Mathematics, Science and Technology Education. 2018 14(1), 61-76.

[2] Wibowo, F. C., et al. (2017). Virtual Microscopic Simulati on (VMS) to Promote Students' Conceptual Change: A Case Study of Heat Transfer. Asia-Pacific Forum on Science Learning & Teaching. 18 (2), 1-32.

[3] Wibowo, F.C., dkk. (2016). Microscopic Virtual Media (MVM) in Physics Learning: Case Study on Students Understanding of Heat Transfer. Journal of Phyiscs: Conference. Series. 739 012044.

[4] Wang, J., Guo, D., & Jou, M. (2015). A study on the effects of model-based inquiry pedagogy on students' inquiry skills in a virtual physics lab. Computers in Human Behavior, 49, 658–669.

[5] Lo, C. K., Lie, C. W., & Hew, K. F. (2018). Applying "First Principles of Instruction" as a design theory of the flipped classroom: Findings from a collective study of four secondary school subjects. Computers & Education, 118, 150–165.

[6] Sarjono, Mardapi, D., & Mundilarto. (2018). Development of Physics Lab Assessment Instrument for Senior High School. International Journal of Instruction. 11 (4), 17-28.

[7] Aljuhani, K., Sonbul, M., Althabiti, M., & Meccawy, M. (2018). Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools. Smart Learning Environments, 5(1), 1-13.

[8] Dobrzanski, L.A & Honysz ,R. 2010. The Idea of Material Science Virtual Laboratory. Journal of Achievements in Materials and Manufacturing Engineering. 42 (1-2): 196-203.

[9] Olympiou, G., & Zacharia, Z. C. (2018). Examining Students' Actions While Experimenting with a Blended Combination of Physical Manipulatives and Virtual Manipulatives in Physics. Research on e-Learning and ICT in Education, 257–278.

[10] Arista, F. S., & Kuswanto, H. (2018). Virtual Physics Laboratory Application Based on the Android Smartphone to Improve Learning Independence and Conceptual Understanding. International Journal of Instruction, 11(1), 1–16.

[11] Engelou, F., & Kotsis., K. (2018): Real vs virtual physicsexperiments: comparison of learning outcomes among fifth grade primary school students.A case on the concept of frictional force, International Journal of Science Education. 41 (3): 330-348.

[12] Gunn, T., Jones, L., Bridge, P., Rowntree, P., & Nissen, L. (2017). The use of virtual reality simulation to improve technical skill in the undergraduate medical imaging student. Interactive Learning Environments, 26(5), 613–620.

[13] Olympiou, G., & Zacharia, Z. C. (2018). Examining Students' Actions While Experimenting with a Blended Combination of Physical Manipulatives and Virtual Manipulatives in Physics. Research on e-Learning and ICT in Education, 257–278.

[14] Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. Computers & Education, 95, 309–327.

[15] Rahmadani, A. F., Hidayat, H., & Syahmaidi, E. (2018). Design of Electronic Elementary Material Learning Module on Vocational Higher Education. International Journal of Scientific Research and Management, 6(01), EL-2018.