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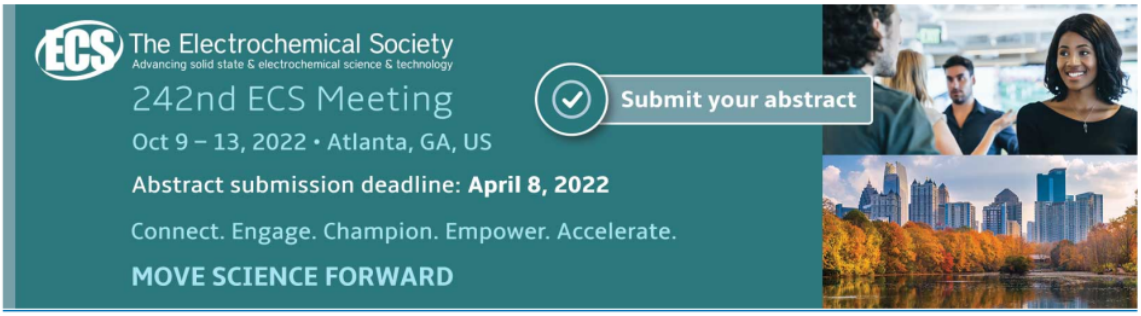

Development of web-virtual laboratory to improve the effectiveness and efficiency of remedial learning

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Abstract. The industrial revolution 4.0 demands universities to improve the quality of the graduates, while the competency standards have not yet been fully achieved. This study aims to build a virtual laboratory (V-Lab) as an independent practicum media through remedial learning. The development of V-Lab used the System Development Life Cycle (SDLC) model with the software Code Codeigniter and PHP 7.2, while the database used MySQL and PostgreSQL. The testing was done with Stub Testing, Unit Testing and inspection with Integration Testing for interactions between modules. The test results showed high feasibility in design, representation of user needs, reliability, security system, and the ease of the usage. The V-Lab is also able to increase the learning motivation of the students and have an impact on increasing student learning outcomes. While efficiency can be improved on the aspects of time flexibility, place of learning, facilities and cost savings because the learning is virtual. This study recommends V-Lab as an effective and efficient remedial learning through a virtual laboratory.

1. Introduction

The industrial revolution 4.0 has an impact on people's lives, demanding an increase in the quality of human resources. Many universities are burdened by the demands of stakeholders. On the one hand, they must improve the quality of graduates in line with the industrial revolution, while on the other hand there are still many internal problems that hinder the achievement of learning standards [1]. Graduates of educational institutions cannot avoid this demand if they do not want to be victims of scientific and technological progress in the era of IR 4.0 [2]. For this reason, universities must re-evaluate the implementation of education and competency standards possessed by graduates.

Learning outcomes are the results of a process that is determined by the adequacy of teaching materials, learning media, and the system used [3]. Competence in Basic Engineering is an obstacle for students to achieve skills competency. The lack of practicum facilities is a major cause of student failure in addition to lack of practicum time and practical work guidance [4,5]. In addition, students experience difficulties in practicum because of the lack of media and limited lecture materials that are generally in the form of print-outs. This limitation is increasingly burdening students to achieve learning goals. This problem does not only occur in the subject of Basic Engineering in the Field of Electricity and Mechanical Engineering, but also in the field of Mechatronics [6] and Physics [7,8].

The Faculty of Engineering, Medan State University faces the problem of low student competence in Basic Engineering. Some efforts have been made one of which is Remedial Learning for students

who fail in regular lectures. But the limitations of learning time especially the lecturers' (instructors) interaction with students make this program ineffective. In addition, the limited practicum equipment and costs add to the burden on students [9]. This condition should not be allowed to continue because it will reduce graduate competence.

To overcome this problem innovative efforts are needed. This study aims to develop a virtual laboratory website (Web of V-Labs) to improve remedial learning through virtual lab simulation. Virtual laboratory (V-Labs) is a laboratory model consisting of interactive multimedia-based computer software that can simulate laboratory activities as if the user is in an actual laboratory [10]. V-Labs also simulates real practicum activities using a simulation program in the laboratory. Not only is the reason for the high cost of equipment, for high-risk and dangerous experiments more precisely simulated in virtual form [11], in addition V-Labs allows visualization or simulation and interacts with an experimental phenomenon in a real laboratory. Thus V-Labs is a web-based learning facility that allows students to carry out learning activities independently through virtual laboratory simulations.

V-Labs has many advantages: more interesting, interactive learning, more efficient time, more effective learning outcomes, learning processes can be done anywhere and anytime, save costs, simplify complicated processes, and reduce the risk of harm [12]. Learning with virtual laboratories is not very different from real laboratories. In fact, in certain conditions learning with virtual laboratories is more effective. In addition, learning with a virtual laboratory can improve the ability to think creatively, train problem solving, increase learning motivation and improve meaningful learning [11,13]. Several studies have shown that virtual laboratories have proven to be effective for learning electrical, electronic, physics, mechatronics, and computer programming practicums compared to real laboratories [5,7,14]. On this basis the development of the Web of V-Labs is considered appropriate as a solution to improve remedial learning.

2. Research method

This research is a development study that builds a learning website for virtual laboratory practices (Web of V-Labs). Web of V-Labs is built based on needs analysis using the System Development Life Cycle (SDLC) model. This model is carried out in four phases, namely (a) Investigation system, (b) Analysis system, (c) Design system, and (d) Implementation system [15]. Later this website can accommodate a variety of remedial learning using simulation software for virtual laboratory practices in various fields.

Web development of V-Labs uses Framework Code Reader software and PHP 7.2 with consideration of advantages in security systems, practical and have faster access. Databases are built using MySQL and PostgreSQL. MySQL with a relational database implementation (RDBMS) of the General Public License (GPL) also provides broad opportunities to users according to user needs.

Web of V-Labs analysis and performance tests follow a life cycle procedure that verifies programs to meet system requirements. System testing is done by Stub Testing to examine the control structure and map the module's performance, and Unit Testing to test the function of each module. At this stage Black Box Testing and White Box Testing are also carried out to re-examine program lines, variables and parameters to be repaired and compiled. The next test is Integration Testing to test the interaction between modules to produce information, and ensure the flow between processes is running correctly. The web feasibility of V-Labs uses the feasibility indicator standard [16]. Furthermore, to analyze the effectiveness and efficiency of remedial learning carried out by a comparative method between regular practicum and V-Labs simulation in aspects of effectiveness and efficiency in terms of pedagogical aspects.

3. Results and discussion

Web V-Labs is built for three access groups, namely (a) administrator; (b) lecturers, and (c) students. Each group is provided a menu as needed. Administrator access has facilities (a) Academic, to manage course data, lecture rooms, study programs, faculties and academic years; (b) Students, to manage active college participants; (c) Lecturers, to manage caregivers for subjects and scheduling courses; (d) Lectures, to manage lecturer assignment letters, scheduling student assessment courses and

management. Lecturer access has facilities (a) Approval of student college participants, student academic data; (b) Lecture management, to manage learning starting from uploading lecture contracts, teaching materials including hyperlinks to YouTube, Google Drive, Dropbox and assignments; (c) Assessment, arranging test instruments, test schedules, assessment and reporting. For students given access (a) Regulatory lectures; (b) Download teaching materials both documents, presentation slides, learning videos, animations and virtual lab simulations; (c) Exams, covering routine assignments, projects, midterms and final semester examinations.

The use of Web of V-Labs in remedial learning is done through online access after getting approval by the admin and lecturer. The following picture is an example of the display of the Web of V-Labs menu for Administrator access facilities and basic electrical remedial learning content in Diode material using virtual laboratory simulations.

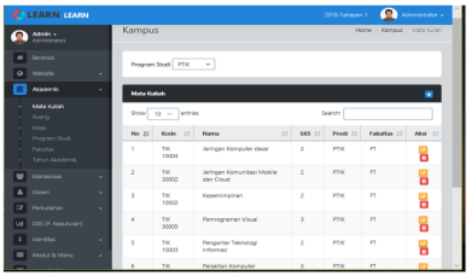


Figure 1. Admin facility on the Web of V-Labs.

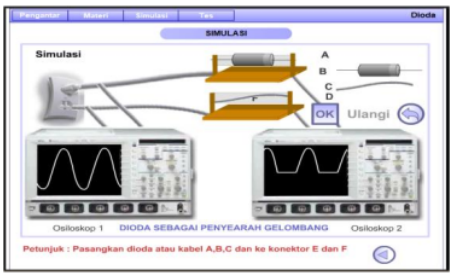


Figure 2. Simulation of the diode function.

The results of the feasibility test of the Web of V-Labs program according to three groups of users namely administrators, lecturers and students are shown in Table 1.

Table 1. Summary of web of V-Labs feasibility test.

No	Testing Aspects	Mean Score of Feasibility		
		Administrator	Lectures	Students
1	**Design**			
	a. operational system	84.63	86.72	90.46
	b. program facilities	91.36	82.64	96.42
	c. navigation	95.28	88.84	92.76
	d. hyperlink	84.62	81.68	94.68
	e. interface	72.56	82.54	95.62
	f. interactivities	86.62	72.54	96.41
	g. visualization	78.37	78.58	96.73
	h. resolution	82.72	76.74	82.65
2	**User needs**			
	a. needs representative	81.40	72.63	98.64
	b. level of usage	76.25	72.83	86.73
3	**Reliability**			
	a. stability	81.40	82.45	94.62
	b. consistencies	82.30	81.63	96.75
	c. compatibility	76.40	75.74	88.91
	d. no-error	78.50	79.75	89.64
4	**Security system**			
	a. ID System	82.43	75.81	95.86

Table 1. Cont.

No	Testing Aspects	Mean Score of Feasibility		
		Administrator	Lectures	Students
	b. program security	76.46	72.54	95.48
	c. multiple layers	84.69	78.52	82.59
5	**Ease of use**			
	a. usability	84.62	85.63	74.86
	b. friendly	90.58	92.64	81.53
	c. help desk system	62.58	65.81	53.68

From Table 1 it is known that in general the feasibility of the program from the web of V-Labs is relatively the same. The difference is only found in the Ease of Use aspect where the average feasibility score according to students is lower than the administrator and lecturer. This is understandable because the ability of students is relatively lower than that of administrators and lecturers so that it gives and pays toward their perceptions. Likewise, on the aspects of design, user needs, reliability and security systems, the average score of feasibility according to students is much higher than administrators and lecturers.

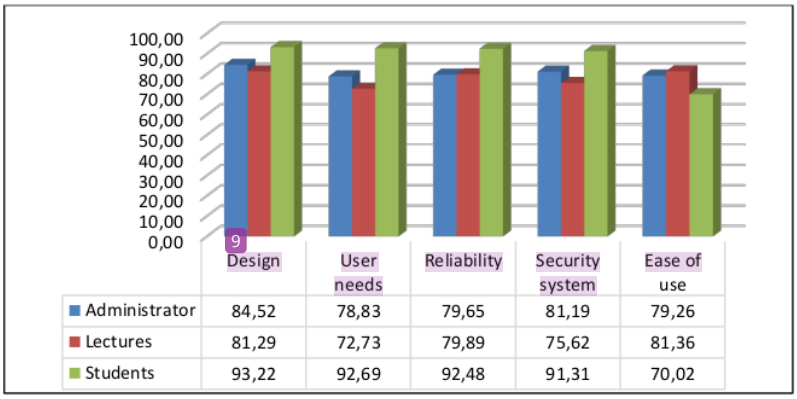
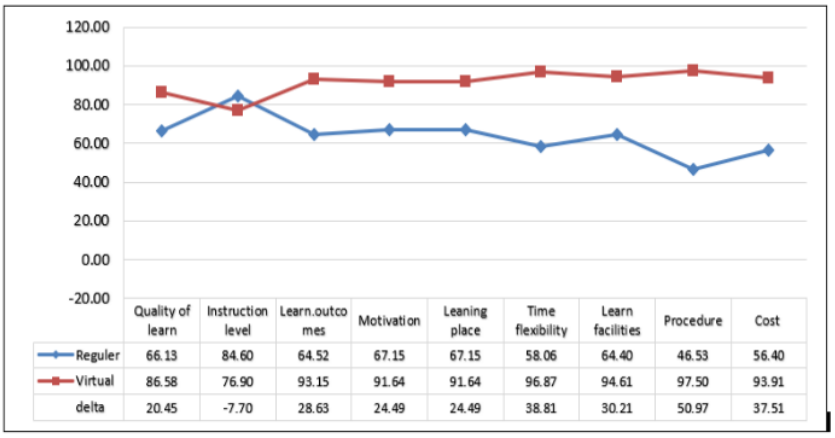


Figure 3. Grade of program aspects feasibility.

If grouped by user, the feasibility score according to students (89.40) is much higher than that according to the administrator (81.59) and lecturers (79.34). The differences in understanding and needs of the three user groups lead to differences in the feasibility score for Web of V-Labs. Overall for the three users the mean score was 83.45 (> 80%). Thus, the Web of V-Labs that were built was declared appropriate for remedial learning in the form of virtual laboratory simulations.

The effectiveness and efficiency of V-Labs Web as a formal learning virtual lab is measured according to the respondents' answers. The effectiveness and efficiency index are measured by the ratio of the average score of students in virtual labs and regular practicum with a standard ratio of ≥1.25. The results of data analysis on the effectiveness and efficiency of learning are shown in Figure 4.



	Quality of learn	Instruction level	Learn.outcomes	Motivation	Leaning place	Time flexibility	Learn facilities	Procedure	Cost
Reguler	66.13	84.60	64.52	67.15	67.15	58.06	64.40	46.53	56.40
Virtual	86.58	76.90	93.15	91.64	91.64	96.87	94.61	97.50	93.91
delta	20.45	-7.70	28.63	24.49	24.49	38.81	30.21	50.97	37.51

Figure 4. Index of effectiveness and efficiency of regular and virtual remedial learning.

Figure 4 states that the Web of V-Labs for virtual practicum learning is more effective and efficient than regular practicum remedial learning. Of the eight aspects measured only the different Level of Instruction, namely virtual lab work is lower than regular practicum, while the other seven aspects of virtual practicum are far more effective and efficient than regular practicum.

From the aspect of Quality of Learning there was an increase in score of 20.45% and Learning Outcomes 28.63%. This finding is in line with the results of Shopi and Eka's research which stated that the use of virtual laboratories succeeded in improving learning outcomes [13]. In line with that research by Perdukova and Fedor also stated that virtual laboratory learning was more effective in improving learning outcomes in the Mechatronic field than regular learning [6]. Several other studies also prove that learning using virtual laboratory effectively improves learning outcomes in the fields of Physics [7, 13], Electrical fields [5], Computer Programmers [14], and Basic Electronics [17].

From the aspect of efficiency in implementing learning, V-Labs is able to increase efficiency with a high category. Efficiency in using practicum time can be increased by 38.81% and efficiency of facility utilization is 40.21% and saves costs 37.51%. While the highest efficiency is the procedure for the implementation of remedial that can increase by 50.97%. The results of this study provide evidence that remedial learning in the virtual laboratory model is not only able to improve the process and student learning outcomes, but also can improve the efficiency of remedial learning as much as an overall aspect of 36.4%. Some relevant studies also reinforce the findings of this study that virtual laboratories are also able to improve learning outcomes and efficiency in learning [13] also increase student motivation and learning activities [4, 12].

Remedial learning uses a virtual laboratory of 24.52% and an efficiency increase of 36.40%. Overall, the use of V-Labs for remedial learning can increase effectiveness and efficiency with an index of 1.43 compared to regular practicum remedial learning. Of the nine aspects assessed, only one aspect of weakness in the V-Lab is Instructional Level, while the other eight aspects of V-Labs are superior to remedial learning with regular practicum.

4. Conclusion

The development of the Web of V-Labs successfully exceeds the standards of feasibility, namely by administrators (81.59), lectures (79.59) and students (89.40). With these results, the Web of V-Labs is worthy of being used for remedial learning. The implementation of remedial learning using V-Labs simulation proved to be better than regular practicum remedial learning with index 1: 1.43. Based on that research recommends using V-Labs in remedial learning because it not only increases effectiveness but also learning efficiency.

Acknowledgments

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