Multimedia simulation model for electrical laboratory learning

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Multimedia simulation model for electrical laboratory learning

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Abstract. Industrial revolution 4.0 demands universities to improve the quality of their graduates. This study aims to find out the improvement of basic engineering competencies through practical learning which is divided into three groups, namely Regular group, Regular-VLabs and Remedial-VLab group. Practical topics are summarized on AC circuits with resistor loads, inducers and capacitors on series and parallel systems. Data analysis using One-way Anova test for comparison of practicum learning outcomes and practicum effectiveness was analysed by gain-score comparison. The results of the study prove that the competence of practicum results in RL-circuit and RC-circuits is high but for RLC-circuit is quite medium. Based on the form of practicum, the competency achievement of the V-Lab group is higher than that of Regular group. The study also proves that the gain score states Regular-VLab are more effective than Regular and Remedial-VLab group. The research findings recommend the use of a V-Labs simulation program for basic engineering practicums especially for laboratories that lack equipment and instructors in an effort to improve basic electrical competency

1. Introduction

The industrial revolution 4.0 demands quality human resources in the field of information technology. This condition causes many universities to be burdened by the demands of stakeholders regarding the quality of graduates. On the one hand they must produce graduates according to stakeholder qualifications, and on the other hand universities still face internal problems related to the lack of educational facilities [1]. In conditions like this, stakeholders still demand the university to produce quality graduates according to the prerequisites of the 4.0 industrial revolution.

In the field of technology there are many stakeholder complaints about the low competency of college graduates [2]. Low professional competence causes graduates to face obstacles in the world of work [3]. In addition, the low competency of the workforce not only has an impact on the difficulty of obtaining employment opportunities, but even worse, employees who have been employed are dismissed because they do not have adaptable competencies to current technological developments [4,5].

The low competency of workers is the main responsibility of educational institutions. The results of the preliminary study found the fact that the low competency of graduates in the field of technology is the low quality of practical learning both due to lack of equipment and the duration of time used for laboratory lab work [4,6]. In addition, the difficulty of achieving professional competency standards is due to the weak ability of students to understand the basic concepts of engineering that are abstract [7,8]. This problem has been going on for quite a long time so it is necessary to think about what solutions should be taken to overcome the problem.

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Learning outcomes are determined by student activities in their learning experiences. The low quality of practicum due to lack of laboratory facilities must be addressed appropriately. One appropriate solution is the use of virtual laboratories, especially for laboratories that lack equipment [9]. This solution is based on research findings that prove the superiority of learning using virtual laboratory simulations (V-Labs). Learning to use V-Labs has proven effective in learning Physics [10], concepts of electric and magnetic [11], computer fields [12,13], automation and robotics [14]. V-Labs is also proven effective for electrical practicum learning and is more efficient and safer [11]. Therefore the low competency of students in basic engineering is expected to be improved through additional practical activities by learning to use virtual laboratories as an effort to achieve professional competency standards.

This study aims to improve the basic competencies of student expertise through virtual laboratory tutorial simulations. The virtual laboratory was chosen because it was considered appropriate for practical learning in laboratories that lacked equipment and lack of instructors and practicum time. Especially with the large number of students and practicum modules that are lacking, the right virtual laboratory simulation is used. With the virtual laboratory practical learning it is expected to improve student learning outcomes while addressing problems of efficiency, practicum time, lack of equipment, limitations of laboratory instructors and costs.

The virtual laboratory (V-Labs) is a laboratory consisting of interactive multimedia-based computer software that can simulate laboratory activities as if the user is in an actual laboratory. V-Labs is part of e-learning, therefore the concepts and characteristics of V-Labs are not much different from the concept of e-learning [6,15]. V-Labs also simulates practical activities that require expensive equipment. High-risk and dangerous experiments are very appropriate to be done through V-Labs simulation. In addition, V-Labs makes it possible to make visualizations or simulations and interact with an experimental phenomenon in a real laboratory [7]. Thus V-Labs is a virtual learning facility that allows students to carry out learning activities as befits a real practicum.

V-Labs learning has many advantages because the learning process is more interesting, more interactive, more efficient, effective, the learning process can be done anywhere and anytime, save costs, replace real events with simulations that may be due to lack of facilities, complicated processes, risks danger, and other reasons [8,16]. V-Labs learning is not different from a real laboratory even in certain conditions V-Labs learning is more effective than real field learning [10,17]. In addition, V-Labs learning is able to improve the ability to think creatively, train problem solving, increase learning motivation and improve meaningful learning.

2. Methods

The study was carried out in the form of a quasi-experiment with respondents from the students participating in the Basic Electrical lecture. Respondents were divided into three groups, namely the real regular practicum group (Reg. Real) as the control group, and two experimental groups namely the regular practicum using the V-Lab simulation (Reg.V-Lab) and the remedial practicum group using the V-Lab simulation. Practical activities are carried out for Basic Electrical subject matter which is considered difficult by students, especially Resistor Circuits, Inductors and Capacitors (RLC-Circuits) in series of series and parallel relationships.

The instructional design uses pre-test, process and post-test. The process is divided into three treatments, namely regular practice for groups (Reg.Real), regular practicum using V-Lab simulation (Reg.V-lab) and remedial practicum using V-Lab simulation (Rem.V-Lab) such as Table 1.

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Table 1. Design of laboratory lab experiments.

Groups	Practicum Activities						
Reg.Real	:		pre test	→	real labs	→	post test
Reg.V-Labs	:		pre test	→	Simulation V-Labs (regular)	→	post test
Rem.V-Labs	: real labs	→	pre test	→	Simulation V-Labs (remedial)	→	post test

Learning outcomes are measured by standard test instruments and are divided into two categories, namely the post test and gain-score score. Data analysis using One-way Anova at $\alpha = .05$ for post test, after testing the requirements for data normality and homogeneity [18]. While the gain-score was analyzed to compare the increase in score of learning outcomes while stating the effectiveness of the practicum in the three student study groups.

3. Results and discussion

Practical learning using V-Labs simulation is the use of computer programs in the form of simulations for practical learning as well as actual practical learning. The following example is a V-Labs simulation program display with material discussing electrical circuits with load resistors, inductors and capacitors.

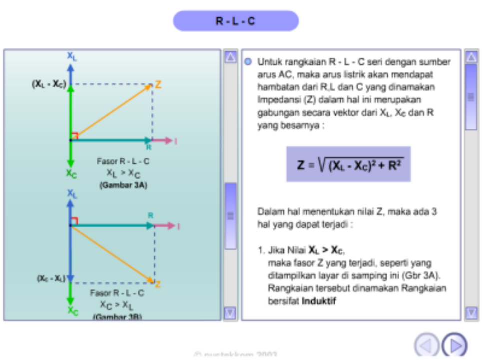

Figure 1. Concept of RLC-circuit.

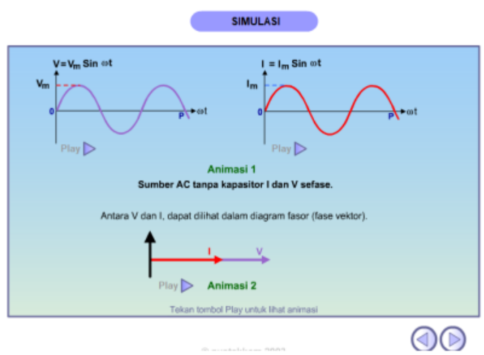

Figure 2. Simulations of RLC-circuit.

Learning outcomes on the topic of Series Sequence and Resistor Parallel load, Inductors and Capacitors from three groups of students showed different scores based on both study groups and based on discussion topics. Table 2 shows the mean score of student learning outcomes.

Table 2. Mean score of learning outcomes.

Groups	Mean Score of Job-Practicum			
	RL-Circuit	RC-Circuit	RLC-Circuit	Total
Reg-Real	82.21	79.13	67.54	76.29
Reg-Sim.V-Lab	83.47	80.11	76.84	80.14
Rem-Sim.V-Lab	87.56	85.51	82.94	85.33
Total	84.07	81.17	74.71	79.98

Table 2 shows that student learning outcomes in the RL and RC series are high compared to the RLC series. This condition is relatively the same in the three student learning groups both Reg. Real, Reg. V-

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Labs and Rem.V-Labs groups. The data shows that in general the RL and RC series students have got good results, but not in the RLC series which is considered more difficult. The results of this study are in line with Setiawan's research [19] although it is less relevant to Mursalin's research [20]. The difference in the effectiveness of the use of V-Labs in the two studies is more due to the initial ability factor that determines the achievement of learning outcomes in the post test. Comparison of learning outcomes scores from the three student groups and three discussion topics namely RL, RC and RLC for series and parallel series shown in Figure 3.

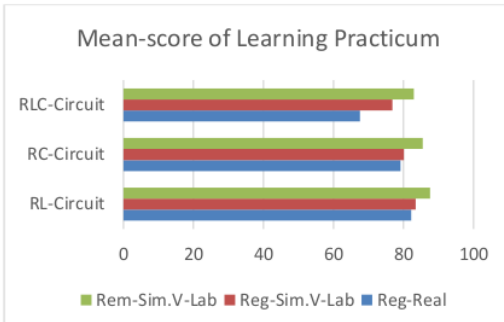

Figure 3. Mean score of learning practicum based on student groups.

In the RLC practicum, only the Rem.V-Labs student group received an average score of 82.94 while the other two regular groups were still below 80. The Reg.Real group received an average score of 67.54 while the Reg.V-Labs group received an average score 76.84. The success of the Rem.V-Labs group is based on the initial ability which is indeed higher because it has carried out the regular V-Labs practice before, while the Reg.Real and Reg.V-Labs groups do not have prior learning experience. Overall, the achievement of student learning outcomes has been classified as high in the practicum material in the RL 84.07 and RC 81.17 but in the RLC practicum it is still quite sufficient with a mean score of 74.71.

Analysis of learning outcomes of all students based on practicum groups shows that the Rem.V-Labs group is the highest compared to the regular group. The Reg. Real group got an average score of 76.29 and the Reg.V-Labs group 80.14 while the Rem.V-Labs group was the highest with a mean score of 85.33. Furthermore, gain-scores in the three student learning groups had significant differences as shown in Table 3.

Table 3. Mean scores and Gain scores based on groups.

Groups	Total	
	Mean score	Gain-score
Reg-Real	76.29	58.51
Reg-Sim.V-Lab	80.14	70.35
Rem-Sim.V-Lab	85.33	22.46

To prove the significance of differences in the average score of learning outcomes, one-way Anova test was conducted. The assumption test results using the Kolmogorov-Smirnov Test get the Asymp value. Sig. (2-tailed) 0.064; 0.210 and 0.326 for the practicum group Reg.Real, Reg.V-Labs and Rem.V-Labs which means the distribution of data in all groups is declared to be normally distributed. The homogeneity test using Levene test obtained significance p = 1.44 and was declared homogeneous at alpha level α = .05. Furthermore, the results of the One-way Anova test obtained F = 29,347 which proved the significant difference in mean scores of the three student study groups.

The gain-score analysis results show the Reg.V-Labs group 70.35 belongs to the high category [21] above from the Reg.Real group 58.51 and the Rem.V-Labs group 22.46. This means that the use of V-Lab simulations is effectively used in practicums and proven to be able to improve student learning outcomes as has been proven in relevant research [1,10].

The results of this study are also in line with previous relevant research that the use of effective virtual laboratory simulation software improves student learning outcomes such as learning Nanostructures [15], Electromagnetic Waves [9], concepts of electric and magnetic fields [11], and practical skills of science [13]. The results of the study provide the fact that the virtual laboratory not only increases the effectiveness of learning outcomes but also increases efficiency. This supports previous research conducted by Gubsky et al [9] and Keeler et al [22]. Thus, virtual simulations become the right solution to improve practical learning outcomes while increasing learning efficiency.

4. Conclusion

The results of data analysis prove the superiority of virtual laboratory simulation as a practical and efficient practical learning model in laboratory practice. Based on the topic of the mean-score practicum the highest is RL-circuit followed by RC-circuit and RLC-circuit. Whereas based on virtual simulation study groups it is very effective to be used by regular practicum group students using V-Lab simulations (Reg.V-labs) compared to the real practicum group (Reg.Real) and remedial practicum groups (Rem.V-Labs). For laboratories that lack equipment, structure and session practicum, it is recommended to use a practical learning model using virtual simulations in order to improve the competency of learning outcomes according to established competency standards.

Acknowledgments

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