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Needs Assessment in Developing Virtual Electrical Machine Laboratory

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***Abstract*— The aim of this study was to investigate suitable multimedia design for the practical course of electric machine. The analysis was carried out by the method of needs analysis and front-end analysis. The analysis was applied in the practical course of electric machine at Department of Electrical Engineering Education, Faculty of Engineering, Yogyakarta State University. The result of this study is to create multimedia based on two or three dimensional in a virtual laboratory model. This virtual laboratory model is the simulation object that is to describe the concept and principles of electric machine work virtually. The virtual laboratory is expected to be an interactive multimedia tool for learners to apply in practical activities of electric machine.**

Keywords*— *virtual laboratory, electric machine, multimedia

I. INTRODUCTION

Vocational education could be used to improve the quality of skilled labor. It emphasizes on the development of learners' competencies on specific jobs. The aim of vocational education is to prepare learners to the world of business and industry. Cited from Law Number 20 Year 2003 regarding the National Education System of Indonesia, vocational education is held in higher education that prepares students to have certain job skills. Education facilities and infrastructures standards must be confirmed to ensure the quality of education. Facilities and infrastructures for practical activities in vocational education are lacking in quantity and quality, as well as lagged behind in terms of technology. These conditions greatly affect the quality of education and the quality of the skills of learners [1]. These conditions will cause graduates have no readiness to enter the workforce. Therefore, practical equipments and laboratories become basic facilities and infrastructures needed for skills' formation for learners.

Software-based learning media is widely applied in the education field. Electronic circuit simulation software and electrical circuit are the examples of software-based learning media. The certain computer software applications could demonstrate abstract concepts in the form of static or animated visualization. The use of software-based learning media could visualize abstract concepts into the form of static visualization and moving visualization. Electric machine is one of the course considered difficult for students. The electric machine course is considered as abstract courses, so it is not easily understood by students. The nature of electricity is intangible, but its existence could be felt and utilized in everyday life. Likewise, the construction of electric machine is tangible, but the principles of the machine are abstract or invisible concepts. The electric machine is an empirical science, so the parameters of the electrical machine need to be supported by experimental results to construct an abstract concept understanding [2]. The abstract concepts of electrical machines could be presented in the form of visualization, thereby facilitating the students in understanding the concept of electric machines.

The application of virtual laboratories in education sector is growing rapidly due to the development of computing technology and graphic design, the concept of virtual laboratory learning can be realized. The development in computer graphics, augmented reality, computational dynamics, and virtual worlds make it possible to develop virtual laboratory [3]. This enables the application of virtual laboratory in education sector to be increasingly massive and intensive. Electric machine laboratory can be simulated by computer-based virtual machines. Electric machine equipment could be created in virtual versions inside the computers with concepts and principles operated as real conditions. The virtualization of electric machine equipment can be used as a means of learning in electric machine practice activities by learners and instructors. The virtual electrical machines of synchronous machine, an example, can be presented with the control of synchronous no-load motors and blocked rotor tests for synchronous generators [4]. The virtual electric machine application is expected to be collaborated with existing practical equipment, so that the learning process of electric machine practice can be done more optimally.

II. Related Works

A virtual laboratory for internet browser-based synchronous machine has been developed. Virtual synchronous machine laboratories are used for testing on synchronous motors on characteristic tests of no-loaded synchronous motors, short circuit tests, and synchronous generators. The effect of learning using virtual labs was also analyzed. The implementation of virtual lab products is done by experimental control group design method. The experimental group used a virtual laboratory, while the control group used a real electrical machine laboratory. Data analysis was carried out by using t-test with the number of students control group of 33 students, while the number of students experimental group was of 40 students. The pretest results showed that there was no difference between the control group and the experimental group. Posttest results showed that there were differences in learning outcomes between the control group and the experimental group. The experimental group learning outcomes were higher than the control group [4].

The virtual simulation environment of nuclear fuel reprocessing has been developed to train workers. This study describes the hardware and software systems into a virtual model. The development of virtual devices includes three-dimensional process models, programming for programming, and the development of communication programs between software and virtual system. The objectives of this development include: 1) simulating how to operate the equipment, 2) demonstrating and optimizing the rationality of the reprocessing procedures in the system, 3) personnel inspection and logistics channels, 4) assisting the development and testing of early maintenance and maintenance procedures; and 5) training of production operators. The results showed that the system performance test was appropriate for the purpose of developing virtual devices; that is for the trainee and showing the design of the nuclear fuel reprocessing plant. Relevance with this research is the use of virtual devices as a medium of learning or training [5].

Automatic control labs using virtual environments have been developed. The developed system is illustrating a water tank filling system. The advantage of this system is that it enables the modification of the initial function by adding controls to the water tank filling device, and analyzing the results obtained during the experiment, as well as performing complex and repetitive tasks in a simple way [6].

III. Material and Methodology

Data were collected by observation and interview approaches according to the needs analysis phase [7]. The analysis phase approach is separated into two parts, namely needs assessment and front-end analysis. Needs assessment is used to assess the gap between current conditions and the desired conditions, as well as to determine instructional objectives. Front-end analysis is a data collection technique used to bridge the gap between current conditions and the desired conditions. Therefore, needs analysis and front-end analysis are interrelated, so the information from the needs analysis provides input on the front-end analysis. Figure 1 illustratesanalysis phase which includes need assessment and front-end analysis.

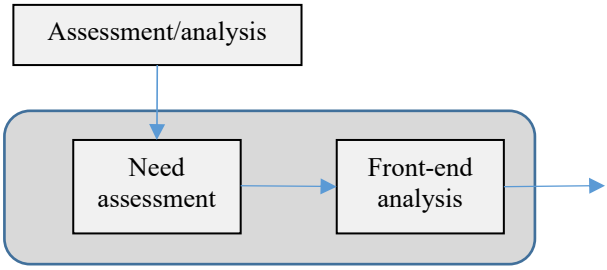

Fig. 1. Analysis phase on developing of virtual electric machine laboratory

IV. Result and Discussion

A. Result

1) Needs Analysis

The practical learning of electric machine course has been carried out by a certain procedure. However, many students failed during individual exams. Students who fail the electrical machine laboratory tests indicated that the mastery of the electrical machine concept has not been achieved. The basic concepts of electrical machine are abstract and invisible, causing the electrical machine concept becomes difficult to understand. The limited number of practice equipment is also a barrier to do practical learning. Two units of electric machinewere used approximately16-20 students. This condition causes the practice experience ofthe learner uneven. Access to the laboratory of electrical machine workshop is very limited due to security reasons. Access is usually provided during lecture hours and accompanied by laboratory technicians during working hours. Access to the laboratories outside class hours is barely provided. This causes the students not have independent learning time outside the hours of the lecture

Ideally, practical equipment is available according to the number of students, or a a machine for 2-3 students. If practice equipment is enough, it is expected that the practice experience can be equally distributed to the students, so as to improve student competence and skills. Access to the laboratory outside of the lecture hours should be provided to support the student's independent learning experiencewith an instructor or technician who accompany the students, to make sure the laboratory always securely and properly used.

The number of practical equipment which is less than ideal conditions causing gaps in the learning that has been done. The lack of availability of the

equipment also leads to uneven practice experience, so the mastery of electrical machine concept will not be optimal which willmakethe competence and skills of learners not optimally achieved ..

The procurement of a new practice tool unit is not always a good solution. Financial constraints and laboratory or workshop areas become a problem when the procurement of practice tool units is used as a solution. The use of multimedia as a substitute for practice unit tools can be used as an effective and efficient alternative solution. Two-dimensional or three-dimensional virtual electric simulators of electric motors can be used to describe the working principles of a system.

2) Front-End Analysis

Front-end analysis is used to extract detailed information related to needs analysis. There are 10 activities in performing front-end analysis. The activities of front-end analysis include (1) student analysis, (2) technological analysis, (3) situation analysis, (4) task analysis, (5) analysis of important events, (6) analysis of current issues, (7) goal analysis, (8) media analysis, (9) existing data analysis, and (10) cost analysis. The front-end analysis data is used to decide whether the gap between the actual conditions and the desired conditions will be bridged by developing multimedia instructional or purchasing multimedia instructional.

Student analysis includes background identification, learning characteristics, and prerequisite skills of learners. The educational background of learners is from senior high school and vocational high school, so it can be said to be heterogeneous. The proportionof vocational learning are 30 percent theory and 70 percent practice, showing that theoretical learning has a smaller portion than practice learning does. Prerequisite skills of electric machine practice is the student has taken the electric machine theory course in the previous semester. Thus, the learner's analysis is focused on the emphasis of the practicum prerequisites, in the form of knowledge of the basic concepts of electrical machinery.

Technology analysis is the identification of existing technology capabilities. Looking at the development of computer technology and information (ICT), ICT-based technology is the most rapid in development and also renewable. The use of computer hardware and gadgets is growing rapidly among learners. Thus, technology analysis is focused on developing computer-based multimedia.

Situation analysis on electric machine practicum is in the form of laboratory environmental constraint or workshop. The current condition of most laboratory or electric machine workshop in open space conditions and the use of props that old technology. Thus, the situational analysis is focused on developing multimedia-based practice tool.

Task analysis includes learning achievement of electric motor practice. Performance to be achieved is that learners are able to test the characteristics of electric machines by using electric machine props. Testing the characteristics of electric machine using electric machine props will be completed with measuring instrument. Students should be able to assemble the installation circuit and operate the electric machine. The parameter data of the experimental test of the characteristic is indicated by measuring the instrument. The test result data is then analyzed to determine the characteristics of an electric machine. Thus, the task analysis is focused on processing experimental data to determine the characteristics of the electric machine.

Critical event analysis on electric machine practice is in the form of knowledge and skill in running or operating an electric machine. Students are required to apply elements of safety while operating an electric machine props. In real terms, the safety element is concerned with the safety of the props and safety of students, where there is an electrical element, especially theinvisible hazard. Thus, the critical event analysis focuses on the safety of students in assembling and operating the electrical machine for the characteristic test of the electric machine.

Objective analysis is the goal to be achieved in electric machine practice. Electric machine practice aims to prove the concept of electric machines through a series of laboratory experiments. The concept of electric machines is theoretically proven through electrical machine practice procedure. The DC motor practice includes a separately DC motor, DC shunt motor, DC series motor, and DC compound motor. Learners are able to prove the characteristics of each type of dc motor. Characteristics of DC motor include: 1) the characteristics of the armature torque to the armature current with the fixed source voltage, 2) the characteristic number of rotation of the rotor to the armature current with the fixed source voltage, and 3) the characteristic number of rotation of the rotor to the armature torque with the fixed source voltage. Knowledge and skills can be provided through hands-on experience when practicing electric machines.

Furthermore, the media analysis includes strategies in delivering media to learners. As ICT development grows rapidly, delivery can be done through restricted storage media. Thus, multimedia can be used independently or through mentoring.

The analysis of existing data includes identification of learning materials, worksheets, references, and lesson plan. The existing data are explored through a study of the practicum procedure that has been running. Electric machine practice through certain procedures require students to mastery a topic of electrical machine material to pass the exam.

Cost and benefit analysis includes identification of costs and benefits and return on investment. The

development of multimedia-based virtual environment model compared to the procurement of new electric machine tool unit is obviously cheaper. The investment is in the form of self-directed learning based on virtual environment, so it is expected to overcome the knowledge gaps and skills of electric machine practicum.

B. Discussion

Virtual laboratory of electric machine needs to be developed to support electric machine practice. The concept of a virtual machine is the same as a real electrical machine laboratory so it is expected that learners can learn to use virtual electric machine before using the real electric machine tools. Electrical machine laboratories are very likely to be developed with reference to previous research, as well as the advantages and ease of using virtual laboratory of electric machines.

Figure 2 can be described, as one of the characteristic testing circuits of the separately excited direct current (DC) motor on load. The separately excited DC generator by varying the variable resistor is used for loading the DC motor. Test results by five different load variations with constant voltage are shown in Table 1. The characteristic graph of Ta = f (Ia) is shown in Figure 3, the characteristic graph of N = f (Ia) is shown in Figure 4, and the characteristic graph of N = f (Ta) shown in Figure 5.

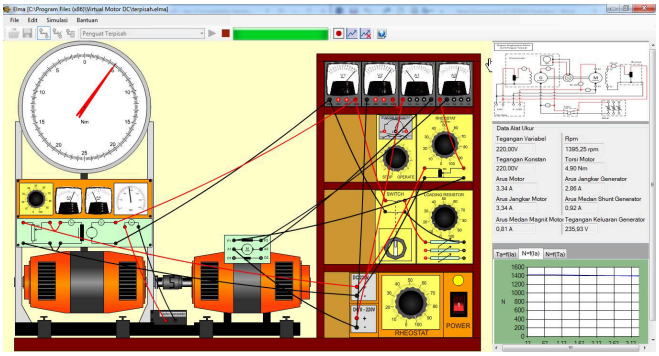

Fig. 2. Testing of the Separately Excited DC Motor on Load using virtual electrical machine laboratory.

TABLE I. TEST RESULT DATA OF SEPARATELY EXCITED DC MOTOR

V_t (V)[a]	I_a (A)[b]	N (rpm)[c]	T_a (Nm)[d]
220	3.73	1569.95	4.93
220	4.00	1568.41	5.28
220	4.25	1566.94	5.61
220	4.50	1565.50	5.94
220	5.00	1562.63	6.60

[a] Vt : voltage terminal.
[b] Ia : armature current
[c] N : rotation per minute.
[d] Ta : armature torque.

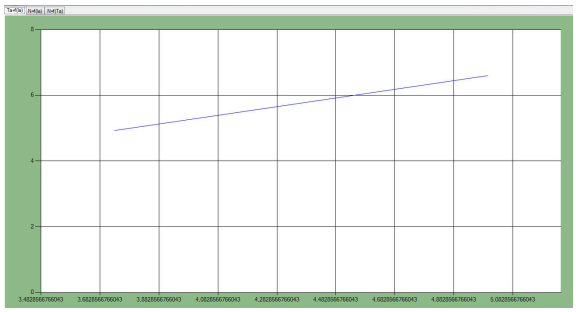

Fig. 3. Graph of Ta = f (Ia) separately excited dc motor

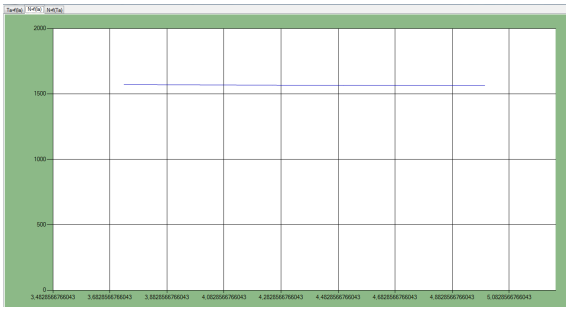

Fig. 4. Graph of N = f (Ia) separately excited dc motor.

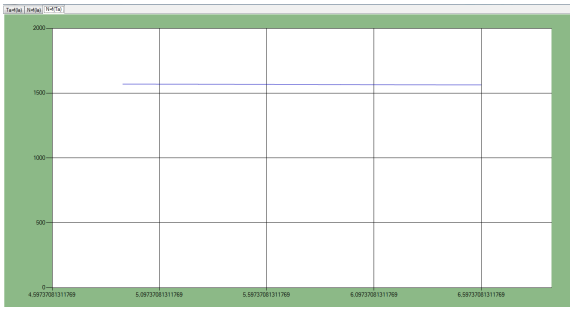

Fig. 5. Graph of N = f (Ta) separately excited dc motor.

The data in Table 1, Figure 2, 3, 4, and 5 can be seen as virtually-animated , indicated by the analogical instrument of ampere-meter and volt-meter and also displayed several numerical data as the result of the simulation program. Other data can be achieved for different kind of testing of DC motor circuits, such as the series DC motor circuit, the shunt DC motor circuit, and the compound DC motor circuits.

V. CONCLUSION

Developing multimedia-based in a virtual environment of two or three dimension model can be developed for electric machine of DC motor course. Two or three dimensional model of real objects in virtual environments can be described to illustrate the concept and working principle of an electric machine. Learners can interact with this virtual environment through a flat screen by on-click event navigation, so they can provide directly practical experiences in

electric machine testing using a virtual environment such as virtual laboratory. This virtual laboratory of electric machine is utilized by simulating the electrical instruments that are developed to support learning process during in practical activities of electric machine testing.

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