An Online Lab for Digital Electronics Course Using Information Technology Supports

By MUCHLAS

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Muchlas
Member of IEEE
Department of Electrical Engineering
Ahmad Dahlan University
Jalan Prof. Dr. Soepomo, S.H., Yogyakarta, Indonesia
muchlas.1962.id@ieee.org

M. Andang Novianta
Department of Electrical Engineering
Institute of Science & Technology AKPRIND
Jalan Kalisahak 28, Yogyakarta, Indonesia
m_andang@akprind.ac.id

***Abstract*—This study is an implementation of information technology for education, aimed to produce a model of online lab course with a collaborative environment using a desktop sharing application. In the digital electronics lab course, participants were divided into the groups, each of them consists of three members. A desktop sharing application was used to the digital circuit simulator as an offline program that can be accessed online. The results show that the application can be used to introduce a collaborative environment in an online lab course. The application was possible to make an offline program such of a digital circuit simulator that can be accessed online by each member of the groups. This model has got a positive response from the participants of digital electronics lab course.**

Keywords—online lab; desktop sharing application; breadboard simulator; digital electronics course

I. INTRODUCTION

Digital Electronics, one of the subjects in the Department of Electrical Engineering, is the prerequisite of the subjects of Computer Architecture and Microprocessors. During the lecture, this subject is delivered through two methods: firstly, direct lecture/face-to-face between lecturer and the students in the class and secondly, the activity was run in lab course. Currently, lab course is run through hands-on activities in the real laboratory by preparing the electronic circuit on the breadboard and testing it using a logic probe. This was done because of its flexibility and low cost for operation.

Unfortunately, practical work in the real laboratory using a hands-on method experiences the problems when the number of students are large. In this case, the main problem is the availability of instruments and electronic parts, also the scheduling as a limitation of lab space. This condition makes the lab course sessions increase drastically exceeds the standard capacity. Based on this fact, it is necessary to develop a lab teaching model that can encourage students/participants remain active and involve in collaboration work, but flexible in the implementation.

Inline with the rapid information technology development, nowdays, there are many learning models created based on the online technique. Many education's experts believe that the online learning is promising method that is flexible and efficient. Even, previous studies have shown that the online lab course has been able to improve the efficiency in funding rather than the practical work using a hands-on method [1]-[2].

The online lab course is possible to be implemented as the internet technology is available to support it. The use of this technology has penetrated into all sectors of human life such as banking, hospitality, travel services, entertainment, news, variety of applications in everyday life, and has great influence on education [3]. Today there are many lab course designs apply the internet facility as one part to support its implementation. This phenomenon introduces the emergence of new terms such as web-based laboratories [4], and web-based experiments [5] that was triggered up by the high access of the internet network at any educational institution especially in the universities and in the family.

To provide similar lab environment as run in a real practical work, the online lab course supported by information technology requires the lab simulator. Many studies have shown that the simulator is effective, efficient and flexible to support practical work activities. The use of simulator in practical work activities can enhance understanding of the material provided [6]. In addition, the use of simulator for supporting the practical work activities can also provide the same effectiveness with hands-on method [7]-[9]. Previous research has also shown that the use of the simulator is more efficient rather than the use of real laboratory [10], and provide conveniently and high flexibility [11].

Regarding the simulator, a breadboard simulator based on Java program has been developed by Bailey and Freeman [12]. However, this simulator is a desktop application that can only be run on the computers with an offline mode. Meanwhile, the lab course will be a flexible learning if it is held in an online mode. Therefore, it is necessary to design the breadboard simulator that can be accessed online by the practical work participants to provide the learning more flexible process and at the same time it can create a collaborative learning environment.

Currently, there are many application programs that can be used to access a computer remotly, to share a desktop screen and to create a collaborative learning environment such as Team Viewer. This application provides all necessary components for a collaborative online learning like video conferencing, and also desktop sharing. With this, it is possible to access an offline-based applications program such as breadboard simulator using an online mode.

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II. Pedagogial Aspect of Online Lab Course

The principle of online lab course is similar to that of the principle to apply the hands-on practical work. The difference is in the media used, in which the hands-on is using a real media, meanwhile the online lab course is using the computer media connected to the other computers equipped with a simulator to replace the real instrument and electronic parts.

According to the learning process aspects, an online lab course is run using the same procedures as the hands-on done. Like the hands-on lab, an online lab course needs an implementation method that can generate interest and motivation and able to guide the students to participate actively in the learning process. At the end of the activity, an online lab course should provide a set of evaluation instruments to measure the student learning's outcome.

Although it is an online mode that distributes the participants into different rooms/locations, this lab course-based internet network should be adjusted to make the participants can collaborate each others during the learning process. Lab course in secondary schools and universities are usually implemented into small groups [13]. The groups will carry out two activities, i.e. cooperation and collaboration forms [14]. Cooperation form is an activity that introduces the group to share tasks, meanwhile collaboration form is an activity among the individual in a group to provide a mutual reinforcement. A collaboration form is very important activity in the practical work because it is potential to motivate individuals in a group. It can be effective media for mutual learning among the individuals.

Evaluation in an online lab course can be done through a portfolio or practical work report that includes an introduction, background, methodology, instrument, results, data analysis, discussion, and conclusions [15]. The whole processes of learning are conducted online, including the evaluation of learning outcomes, for example by submitting a portfolio to virtual laboratory prepared to support this online lab course.

III. Breadboard Simulator

A software that can be used to support the online practical work activities in Digital Electronics is a breadboard simulator. This simulator provides virtual instruments and electronic parts, consists of a breadboard with its power supply, various types of IC logic TTL (transistor-transistor logic), switch components, 7-segment LED display, wiring and logic probe. This software is a desktop application based on Java program that can only be run using a local computer under Windows operating system. Nevertheless, this program has an advantage, it can provide virtual devices and simulation features for a general logic circuit design both combinational and sequential circuits [16].

It is important to note that the operating requirements must be adjusted to allow the breadboard simulator working properly based on the available hardware and software. This simulator requires a hardware like a desktop or laptop computer with standard specifications for desktop applications operation. The desktop or laptop computer is mandatory to use Windows operating systems such as Windows XP, Windows Vista or Windows 7, and the plug-in Java Runtime Environment [17].

A. User Interface

The user's interface of breadboard simulator is a main window that is similar to the other application programs. This window is the most important graphical user interface of the program. The structure consists of menu, toolbar, selection pane, dipswitch component, status bar, wires, probes, chips, LEDs, breadboard, circuit pane, and logic probe bar.

By using this interface, the user can plug a breadboard and digital components required. For more complex digital circuit designs which require more wide board sizes, this simulator provides a multi breadboard access. With this, the user can display many breadboards on this main window. Interface visualization of this simulator is similar to the breadboard used in hands-on practical work. Figure 1 shows an example design of 4-bit shift register circuit using chip 7474.

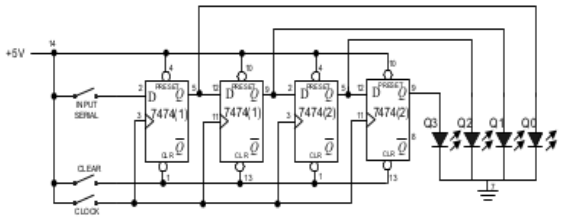

Fig. 1. Four bit shift register using 7474 chip.

From the circuit shown in Figure 1, if 4-bit shift register is implemented using a breadboard simulator, the result obtained is shown in Figure 2.

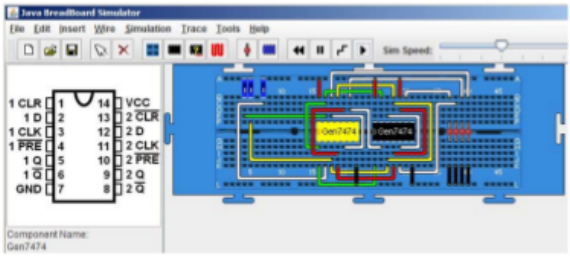

Fig. 2. User interface of breadboard simulator for 4-bit shift register.

B. Simulation

Breadboard simulator provides a variety of simulation to display the characteristics of circuit prepared. By using interface, user can select continuous simulation mode (run) or step by step mode. In the step-by-step mode, the program will execute data every 1 ns. Generally, a testing of digital circuits is done using a run mode because more simple and the user can interact directly with devices installed on the breadboard.

IV. Online Media for Collaborative Learning

Online lab course can be implemented by dividing the class into small groups for member of three persons in each

group. Each group was guided by an instructor. With this, one member of an online group consists of three students and one instructor. This online lab course requires the information technology facility as shown in Figure 3.

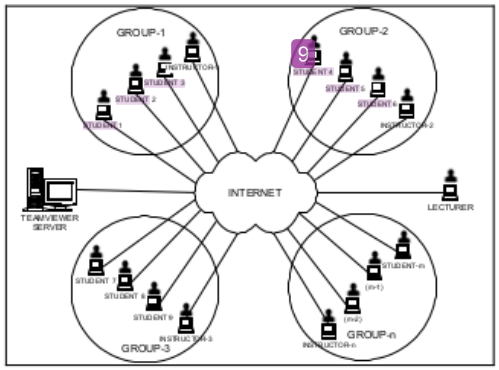

Fig. 3. Diagram of facility for an online lab course required.

Beside requiring the hardware and internet facility, the design of an online lab course also requires software support. To support the growing of a collaborative environment, we needs two conditions of : (1) availability of an offline breadboard simulator that can be accessed in an online condition and (2) provide an online media that can serve the video conferencing, voice calls (VoIP) and text conferencing. One of the software that can support both steps are TeamViewer program that providing the application of desktop sharing and collaboration online.

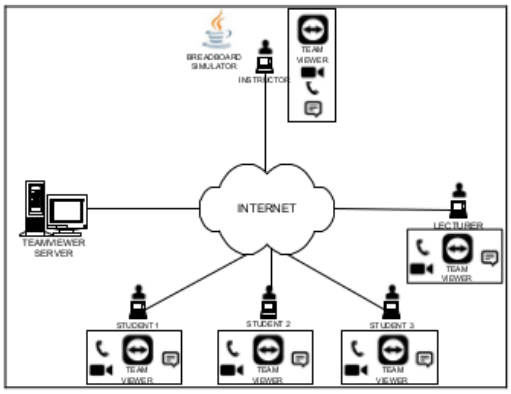

Fig. 4. Diagram of a desktop sharing application for accessing breadboard simulator.

Online meeting application of Team Viewer program provides features required to make a collaborative environment in an online lab course like video conferencing, audio conferencing and text conferencing. In addition, the online meeting application also provides the desktop sharing feature that can be used as a media to access online the desktop application-based program run on a computer. Figure 4 shows an illustration of online access to breadboard simulator in an offline condition by another computer in an online lab course. Figure 5 shows its screenshot display.

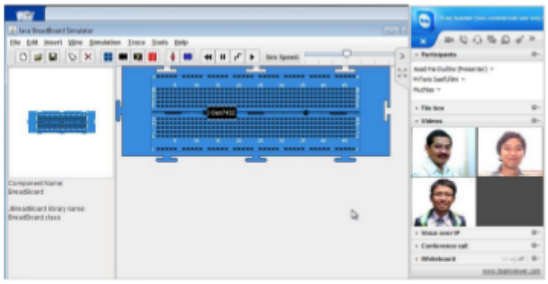

Fig. 5. A screenshot display of a share desktop.

V. Experiment and Result

An online lab course in Digital Electronics has been implemented in 8 sessions that covers the topic of: (1) Characteristic of Basic Logic Gate; (2) Designing of Combinational Logic Circuit; (3) Comparator and Binary Adder; (4) Multiplexer and Demultiplexer; (5) Encoder and Decoder; (6) Flip-flop; (7) Counter; and (8) Register. Pre-test was given to subjects at the beginning in every session, and post-test at the end of the session. To find out the description of the subject's perception, at the end of the online lab activities were given a questionnaire of perception.

Before running the online lab course, each participant sends a preliminary task to the instructor via the virtual laboratory portal based on CMS (Content Management System). This task will be corrected by the instructor, each participant will get the feedbacks online. Instructor gives an assessment for this task and the results will be put into the database as one element of evaluation.

Implementation of an online practical work is initiated by the instructor, by inviting the participants to join the meeting using Team Viewer program. The process is carried out by the instructor by sending the password to the participants and the teacher through communication facilities such as a chat. After all the participants in one group join the online meeting, the instructor and participants have to make sure that each of them can do video conferencing. For the next step, the participants working on an online pre-test supervised by the instructor through the video conference feature.

The next procedures, the instructor was running the breadboard simulator and setting up the online meeting panel to allow the participants access the breadboard simulator online. Furthermore, all participants in each group will prepare a logic circuit on the virtual breadboard, collaboratively. Through this procedure, the instructor can monitor the activity of the participants via desktop sharing and video conferencing features. The instructor will record the participants' activity and put it into the database as an assessment's result of the process. Meanwhile, the lecturer can visit and give an advice to the participants via joint on meeting with the group. The online lab course was ended by the post-test activities online. All participants will prepare the portfolio or practical work report individually, they will submit it to the virtual laboratory portal. From the experiment done to 8 sessions, the results are given in Figure 6.

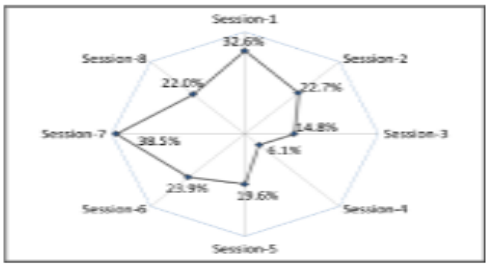

Fig. 6. Results of a learning impact of online lab course.

According to Figure 6, the online lab for Digital Electronics course can give a good influence on the improvement of learning outcomes. All sessions of practical work have given an increase on the learning outcome averaged by 22.5 %. Interesting finding occurred in session 4, which shows the lowest increase of 6.1 %. This lowest value is due to the difficulties experienced by the students to identify the input and output pins of the multiplexer and demultiplexer (topic in session 4). This similar result was also observed by Herman et.al. [18]. It is important to note that in the topic of multiplexer and demultiplexer, the use of online practical work does not affect significantly to improve learning outcomes.

From the perception aspect towards the implementation of online lab course, response of the students can be visualized in Figure 7.

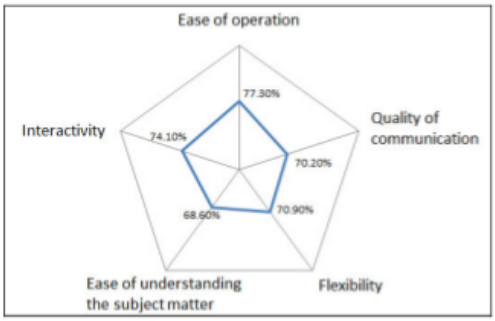

Fig. 7. Student's perception towards online lab course.

From that figure, it is shown that understanding aspect of the material has the lowest perception compare to the other aspects. This can be happened because the students experienced a misconception during the lesson. Perceptions of interactivity and ease of operation are found to be high. This shows that the model is quite acceptable by the students and at the same time it can create an online collaboration environment as expected. Similarly, on the quality aspect of communication which have high perception, this indicates that the online practical work are not overly constrained by the communication facilities. The study also found that the TeamViewer software and the breadboard simulator can be used as a flexible online learning tools. Generally, it can be argued that the online lab course obtained a good perception of students with an average percentage of 72.22 %.

VI. Conclusion

This study has shown that the combining between the desktop sharing software and breadboard simulator can be used as an online media of lab course, especially in Digital Electronics. The online practical work model using both applications have also been able to create a collaborative learning environment and got a positive feedback from the participants of the online lab course.

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