Online Remote Laboratory for Open Distance Learning

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Abstract

Conducting laboratory experiments is a major barrier where open and distance learning is concerned. When the Open University of Sri Lanka is considered, most of the laboratory facilities are available only at the central campus and laboratory experiments are not delivered by distance mode. With the introduction of Online Remote Laboratory, carrying out experiments via internet is made possible. Hence students can perform experiments from anywhere in the world. However this system is not a complete replacement of the traditional laboratory facilities. Hands on experiences such as patching and familiarization of equipments have to be gained through real laboratory experiments conducted at preliminary levels. On the other hand a remote laboratory can be utilized as a useful educational tool to acquire pre-experience before entering the real laboratory facilities and also help to re-perform the experiments in order to get more practice. The bipolar junction transistor amplifier experiment was selected as the prototype remote experiment. The Online Remote Laboratory website supplies the guidelines and relevant materials so that the students have the opportunity to perform given tasks of the experiment remotely, using real equipment/components as well as to obtain measurements. They can download the application software from the website and connect on to the remote laboratory by entering their credentials. The users are able to view laboratory environments using a controllable camera which provides the real sense of the experiment. Before and after the experiment, the users' knowledge could also be examined by an online questionnaire.

The remote laboratory was tested with a group of students. As expected they acquired the same knowledge as the students who performed the experiment in the actual laboratory. Most of the existing open distance e- learning systems are confined to delivering lectures, course materials and online quizzes, but this product can be used to deliver laboratory experimental experience in the context of e-learning.

1 INTRODUCTION

Open Distance Learning (ODL) is an educational mode that employs pedagogical, technological and instructional design strategies to promote a blended learning environment to those who miss the opportunities for higher education on account of employment, time, space, income and other obstacles[1]. Face to face laboratory sessions in present ODL systems do not match with those ODL objectives.

The Open University of Sri Lanka is an open and distance learning educational organization. However unfortunately the university laboratories are not equipped in distance mode[2]. Therefore many problems arise when attending laboratory experiments. Especially if a student is unable to attend a relevant session, the university finds it pretty much impossible to

rearrange a new session and that the students have to re-register. Hence performing laboratory experiments is a major barrier when delivering engineering curriculum in distance mode.

The Online Remote Laboratory (ORL) system present in this paper, can overcome above difficulties and using it student could perform laboratory experiments at flexible times, from anywhere via internet. This system also can utilize to sharing resources among universities and other educational organizations.

The linear cascade lab facility is a remote laboratory experiment at the Department of Energy Technology at Royal Institute of Technology, Sweden [3]. Remotely-located students can operate this laboratory from anywhere using the internet after contacting the coordinator. This laboratory is not available for 24 hours as it requires the presence of the coordinator. This particular remote laboratory is an embedded one and is specially design for specific experiments only without any customizations. The system presented in this paper, can be accessed for 24 hours and it does not require the presence of the coordinator at the laboratory. Our ORL can also be easily customized to perform other experiments by making minor changes to the system. It uses TCP/IP protocol for communication via internet [4]. Prototype ORL use Tektronix AFG 3011 single channel signal generator[5], GW Instek GDS 806S oscilloscope[6] and personal computer as test bed. Joomla open source software [7] is used to developing the ORL website and Microsoft Visual Basic 6.0[8] used to developing ORL server and client software.

2 PROBLEM IDENTIFICATION

When the Open University of Sri Lanka is considered, distance learning education is delivered using printed course materials, day schools, CD/DVD lecture series, assignments, examinations and laboratory practical sessions. It has six regional centers and eighteen study centers Island wide for delivering day schools/exams. Submitted assignments are corrected & sent back using postal service or virtual classes. Lecture notes can also be delivered using virtual classes, but unfortunately not the laboratory experiments. As most students are working while studying they face a lot of difficulties when attending laboratory sessions. The allocated time period for laboratory sessions is very much limited (on average 3 days per subject) which makes it even more difficult for students to study further about experiments before or after the scheduled practical session. Although students use study centers of the Open University Island wide for their studies, laboratories/equipment/apparatuses facilities are mostly confined to the Central campus.

A feasibility survey to find out students' attitudes on the present laboratory system and purposed remote laboratory system has been carried out and elaborated below.

Registered students in 2010/11 and 2011/12 for MEX3272 Applied Electronic course under Mechatronics Engineering curriculum in the Open University were selected as the sample. Fifty one students were registered for MEX3272 in 2011/12 academic year and we have collected data from 28 students. Also data from 9 students from academic year 2010/11 has also been collected.

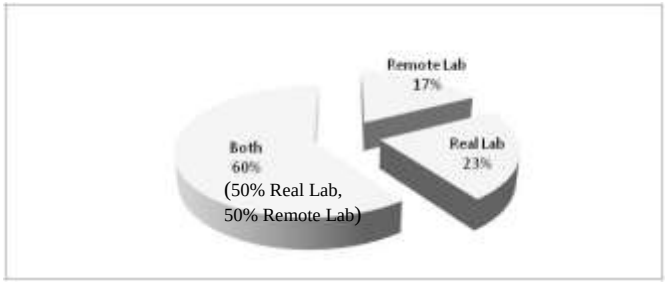

Figure 1 - Selection of laboratory methods by students

According to the survey, if a remote laboratory is introduced they would like to use it along with the traditional laboratory experiments at Central campus in Nawala.Most of them do not suggest to complete replacement of the current laboratory system by ORL as shown in Figure 1. Therefore first stage is to introduce the ORL along with the current system (50% experiments in ORL and 50% experiments in real laboratory) as an additional tool for learning. Even when the remote laboratory is fully developed with all necessary facilities, the current laboratories must not be replaced as they need to be used whenever necessary to get more practical experience. However the integration of the remote laboratory would reduce the current laboratory session duration, whereas most of the students who are employed prefer the remote laboratory rather than the current laboratory system as shown in Figure 2.

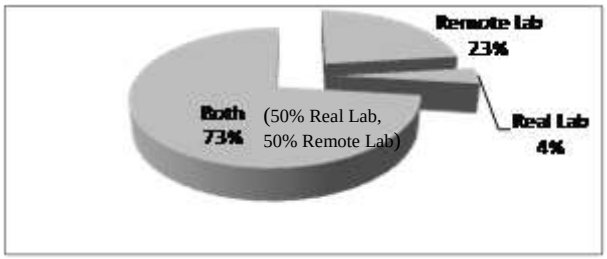

Figure 2 - Selection of laboratory methods by employed students

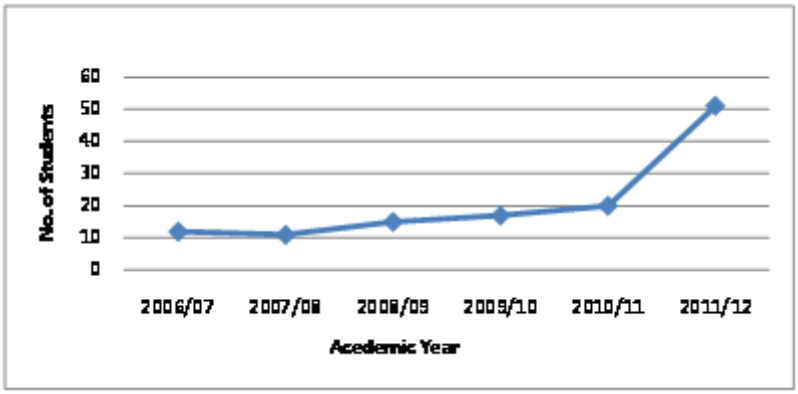

Figure 3 - Students registered for MEX3272

Therefore, the need to develop tools such as remote laboratories to offer laboratory facilities is very important in an open environment where students have to study and work. Figure 3, clearly shows an increment of the number of students registered, and therefore a method need to manage & share the limited resources among all of them is a must.

3 PROTOTYPE EXPERIMENT

The demand for Mechatronics Engineering is increasing rapidly. As a result there is an increase in student registrations under that curriculum. That is why Mechatronics Engineering was selected for our experiment. The Number of students studying in the Advance Certificate in Technology program (level 3) is greater than that of Diploma & Degree program. Hence we decided to perform the experiment in the level 3 course.

According to the compulsory courses list.[2] MEX3272 & MEX3273 subjects are specially offered to Mechatronics students with lab sessions. MEX3273 and MEX3272 offer Matlab practical session and offer applied electronic lab session respectively. Therefore we decided to offer MEX3272 experiment via remote lab. It includes experiments as such (1)Bipolar Junction Transistor(BJT) amplifier;(2)Logic gates;(3)Linear circuit;(4)Analog & digital circuit simulation using workbench;(5)RC timing circuit. RC timing circuit is only a simulation practical.The lab session on logic gates does not require any instruments. From other experiments, No**.** (1) was selected as the prototype to implement via remote lab by considering their requirements.

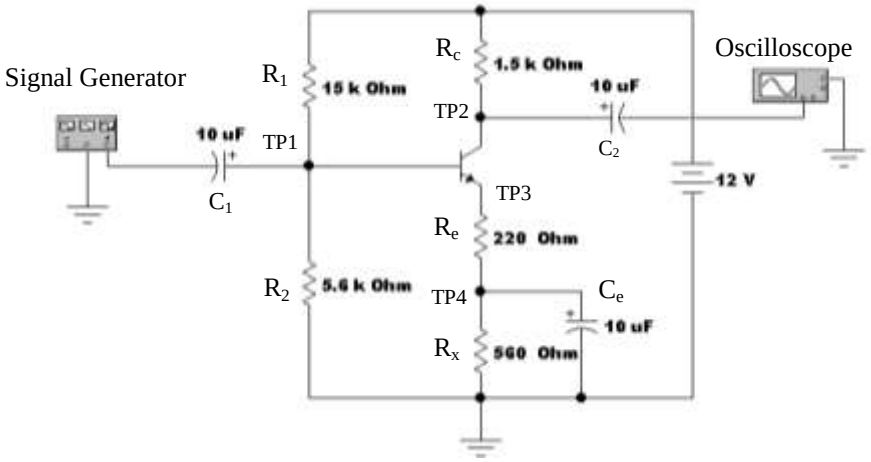

Figure 4 - Experiment circuit diagram as present lab sheet.

4 METHODOLOGY

According to the lab sheet, the tasks are, calculate the voltages at the test points(TP) 1,2,3,4 as shown in Figure4, and find AC gain, identify the biasing network/functions of capacitors/function of Rc resistor, give V_{in}(voltage input) as 0.2 Vpp at 5 KHz from signal generator & monitor V_{in} & V_{out}(voltage output) by dual channel oscilloscope, measure V_{out} of the amplifier with V_{in}(0.2-2.7V) at 5KHz,from these reading draw a graph of V_{out} vs. V_{in} and find the AC gain, measure the maximum output swing, monitor the output voltage and test point voltages by disconnecting C_e capacitor and comment on the result, identify at least three common faults of the amplifier. Therefore a methodology was developed to give and change inputs of the experiment remotely, change parameters and observe the results via internet.

4.1 SYSTEM ARCHITECTURE

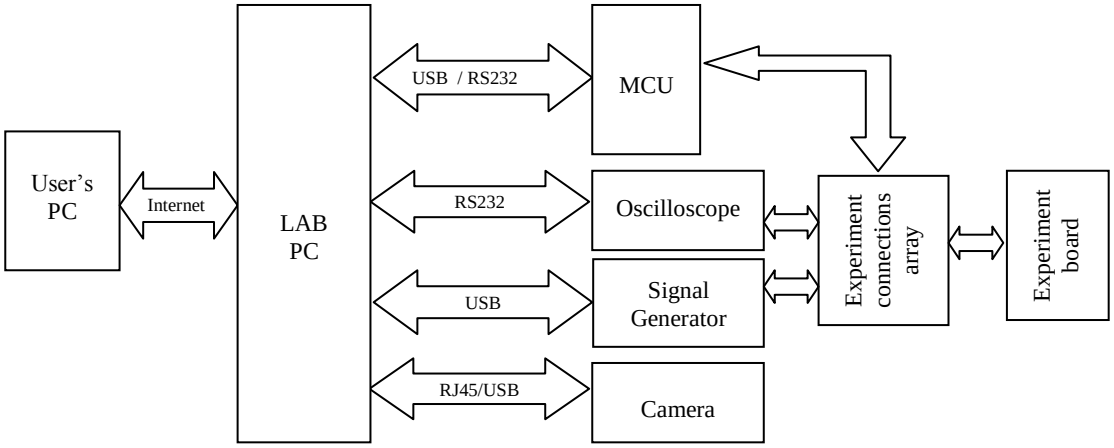

Figure 5 - Block diagram of the experiment hardware setup

An experiment board was developed with open connections for relevant input, output and test points. The connection points were connected to develop a connection array using relay switches. All measuring equipment were connected to experiment board via the connection array which was controlled by a microcontroller unit (MCU)[9]. MCU was connected to laboratory computer via USB (Universal Serial Bus) or RS232 communication bus. The MCU catches relevant commands passed by ORL server software and according to the given commands makes connections to the experiment board. The commands are passed on to the MCU by ORL server software developed for this purpose. Also whenever there are limited connections in the experiment, the connection array can be directly connected to the RS232 or parallel port of the computer [10]. However the use of MCU in this system provides for easy customizability and future expandability not only to change connections, but also to control actuators, motors using MCU remotely.

4.2 INSTRUMENT CONTROLLING

Considering the available instruments in the University, GW instek GDS 806S - 2 channel oscilloscope and Tektronix AFG 3011 single channel signal generator were used for the ORL. GW instek GDS 806S - 2 channel oscilloscope has RS232 communication interface and Tektronix AFG 3011 single channel signal generator has a USB interface. Both instruments work with IEEE-488.2 and SCPI (Standard Commands for Programmable Instruments) standards [5,6].

When a command is transmitted to the instrument, the following three basic elements of SCPI command syntax named i) command header, ii) parameter, and iii) message terminator or separator are considered.

Ex:- :TRIGger:DELay:MODe <Boolean> ;

command header parameter separator.

Data types of SCPI are boolean, integers, decimal numbers, and floating point numbers.

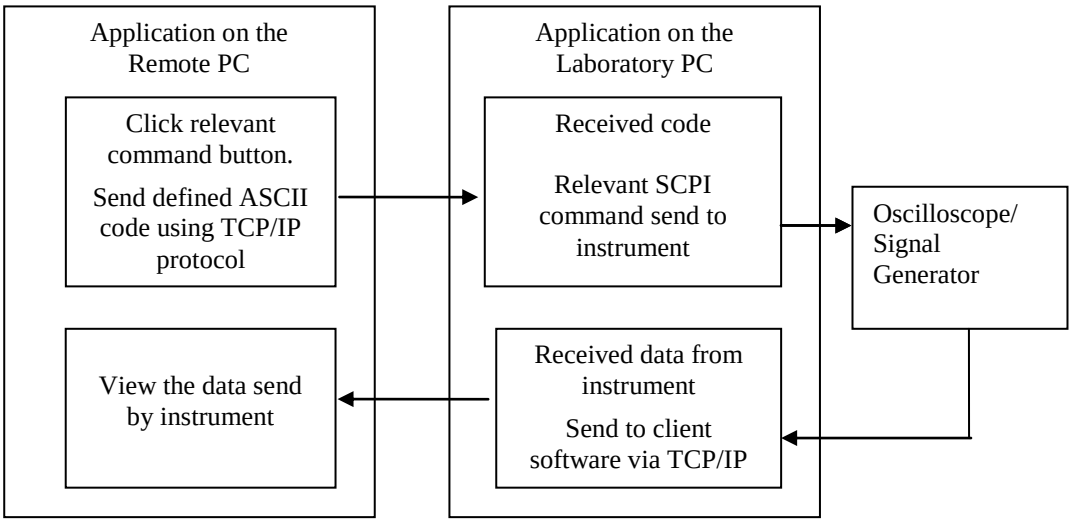

Figure 6 - Communication with oscilloscope and signal generator

The RS-232 interface of this oscilloscope is configured as an RS-232 "Data Terminal Equipment". Data is read from the oscilloscope by developed software using relevant SCPI command. SCPI command sends serial data via PC-RS232 to oscilloscope's RS232 interface. The corresponding reply is sent via oscilloscope's RS232 to PC-RS232. This signal generator has a USB Interface only. Therefore USB data are accessed by the system through VISA(Virtual Instrument Software Architecture) software. Then the signal generator can be controlled using SCPI commands.

4.3 SOFTWARE OF THE SYSTEM

A software was used to communicate between server (lab) PC, client (student) PC, MCU and instruments. Student can logon to the ORL website by accessing the URL and can download an ORL client software. That software is used to perform the experiment remotely and the commands given by the students are passed to the ORL server via TCP/IP protocol. Students can download learning materials and can view the laboratory environment through a camera to get a feeling of the real laboratory. That concept is shown in Figure 7 and is also explained in flow chart shown in Figure 8.

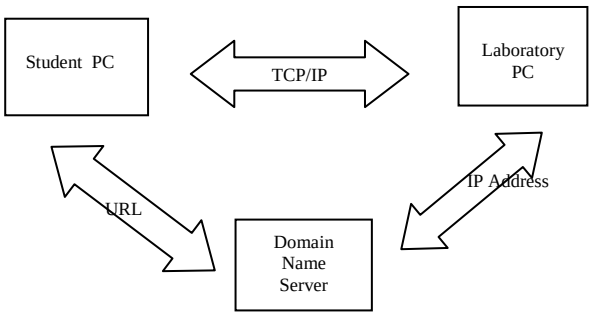

Figure 7 - Block diagram of connection between Client & Server

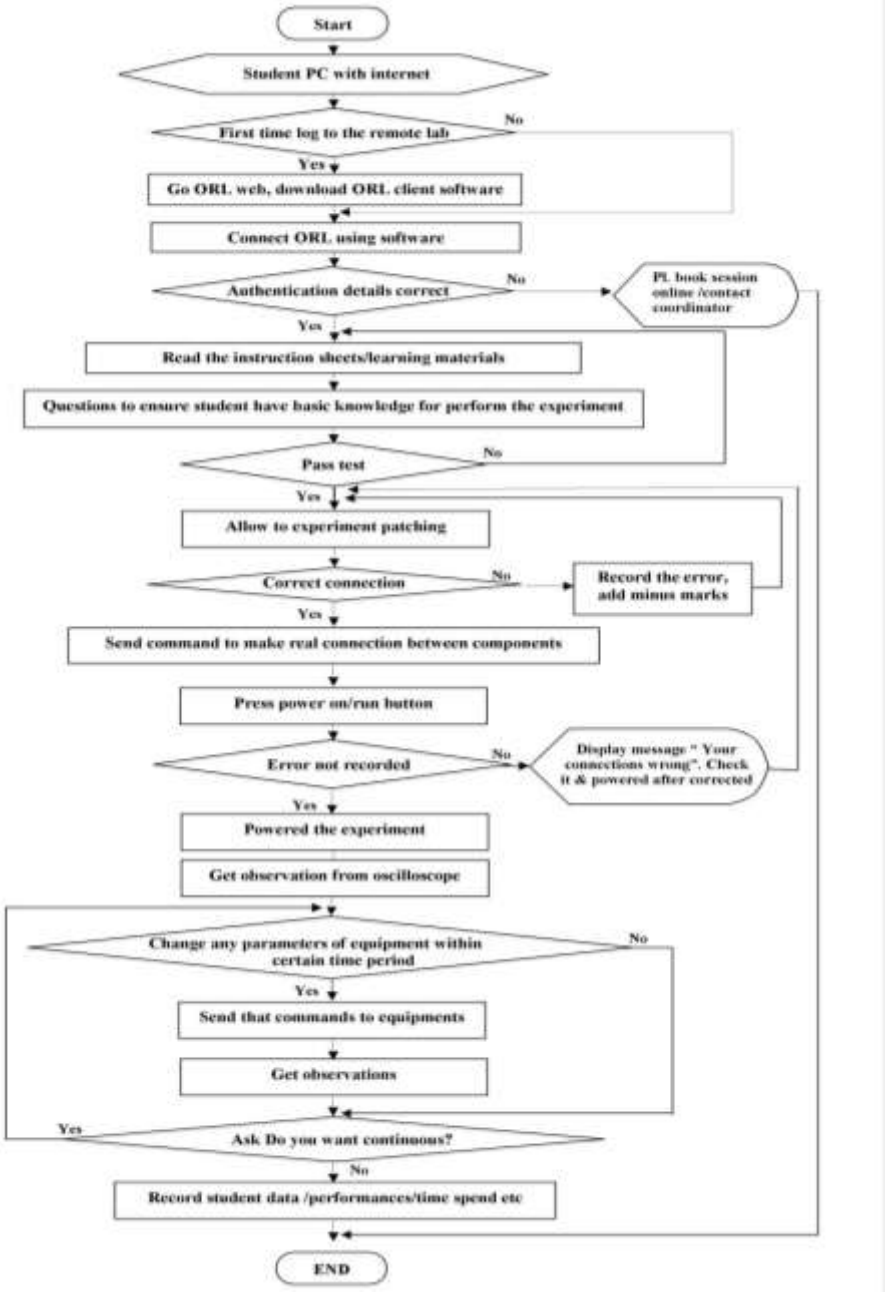

Figure 8 - Software sequence flow chart

ORL Website provides ORL client Software download facility, course materials, guidelines and other information to students. Joomla, a free open source solution is used to build the website[7]. XAMPP Control Panel with Apache, MySql and Mercury services are used for website publishing. Students can access the website after registering and the administrator has an ability to manage users' privileges by using user manager as shown in Figure 9.

Figure 9 - User manager

Users can access the main menu, software download link and live video of the laboratory after logging by using an activated user account as shown in Figure 10.

Figure 10 a - Before logging the ORL web

Figure 10 b - After logging the ORL web

Figure 10 – ORL website

Online Remote Lab server and client software are developed using Microsoft visual basic 6.0. ORL server software runs on the laboratory PC and it connects to the oscilloscope via RS232 port and MCU control circuit connect to PC via USB or RS232 port. Oscilloscope, Signal generator and MCU can receive and send data via TCP/IP protocol and use three separate ports for it within the same host. Users can change the oscilloscope connections to relevant test points and also can measure voltages, frequencies, change oscilloscope vertical/horizontal scales etc. User have the facility to change frequency, amplitude and functions of the signal generator too.

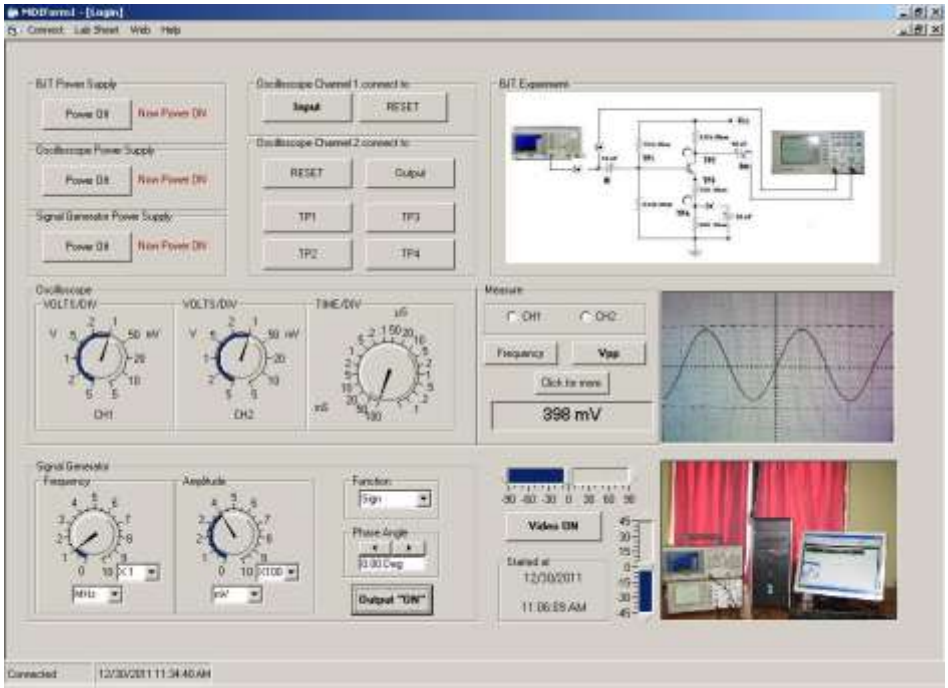

Figure 11 - Online Remote Lab client software

5. EVALUATION

Average results that were analyzed after performing the experiment in a traditional laboratory and ORL by selected sample students are illustrated here. A Sample was selected from average students according to their past records and was divided into two groups A and B. Both groups get nearest average marks as shown in the Figure12.

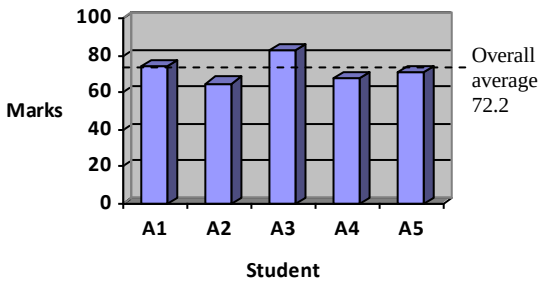

Figure 12(a) - Real laboratory experiment

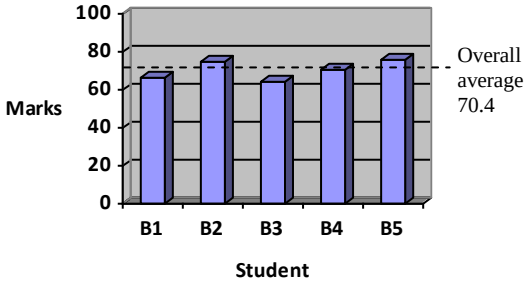

Figure 12(b) - ORL experiment

Figure 12 - Students evaluation results after perform experiment

6. CONCLUSION

According to the results, knowledge transfer of the both laboratory methods are the same. Therefore, the primary objective can be achieved by ORL. In addition, the objectives of Open Distance Learning can be achieved by this system. The difficulties that distance learning students face when participating in face to face laboratory sessions can be reduced by this system. On the other hand the number of face to face laboratory sessions can be reduced and is helpful to working students. One of the main objectives of ODL is to provide learning environment to those who miss the opportunities for higher education on account of employment, time, space, income and other obstacles. This system is helpful to achieve the above objectives.

7. REFERENCES

[1]. Open & Distance Learning. (2011). *Open & Distance Learning* [ONLINE] Available at: http://www.ou.ac.lk/index.php/component/content/article/35/90-open-a-distance-learning.[Accessed 20th July 2011].

[2]. The Open University of Sri Lanka(2011).*Prospectus,Faculty Of Engineering Technology 2011/12* Available at http://www.ou.ac.lk/eng/images/stories/ENG/prospectus_2011e.pdf [accessed 10th June 2011].

[3]. Navarathna.N, Fedulov.V, Martin A, Fransson, T. (2003). *Design of a remotely-controlled laboratory exercise in aerodynamics*.[ONLINE]Available at: http://www.energy.kt-h.se/proj/projects/Remote_labs/Publications.asp [accessed 14th June 2011].

[4]. Andrew S.T, (2009). *Computer Networks*. USA: Prentice-Hall p611-714

[5]. Test and Measurement Equipment | Tektronix.(2011). *Test and Measurement Equipment | Tektronix*. [ONLINE] Available at: http://www2.tek.com. [Accessed 10th October 2011].
[6]. Welcome to GW Instek. 2011. *welcome to GW Instek*. [ONLINE] Available at: http://www.gwinstek.com/en/product/print.aspx?pid=177&mid=85&id=51. [Accessed 5th October 2011].
[7]. Joomla!. 2011. *Joomla!*. [ONLINE] Available at: http://www.joomla.org. [Accessed 7th October 2011].
[8]. MSDN Library . 2011. *MSDN Library* . [ONLINE] Available at: http://msdn.microsoft.com/library/default.aspx. [Accessed 10th October 2011].
[9]. Predko,myke (2008). *Programming and customizing the pic® microcontroller*. 3rd ed. USA: Mcgraw-hill. P1-320.
[10]. Karunananda A.S. (2001). *Pariganakayen Thawath Weda*. Colombo: Author. p150-182.