AC 2011-914: USING VIRTUAL AND REMOTE LABORATORY TO ENHANCE ENGINEERING TECHNOLOGY EDUCATION

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Using Virtual and Remote Laboratory to Enhance Engineering Technology Education

Abstract

Enhancement of teaching, laboratory and human development by virtual and remote laboratory designs cannot be over-emphasized. In this paper, progress made in the development of a Virtual and Remote Laboratory (VR-Lab) for Engineering Technology is presented. Authors have used prevalent technology to develop new Virtual and Remote Labs for Direct Current and Data Communications experiments. The VR-Lab system framework, interfacing and facilities are also presented. Gains of positive outcomes on inter-university cooperation, and student development are reported. Reactions from student users through experiment performances and surveys were gauged and used in perfecting the VR-Lab designs. The effect on curriculum development is considered.

Introduction

Information technology has had a great impact on education, by providing additional teaching strategies such as online learning. The 2009 Sloan Survey of Online Learning revealed that online learning enrollment rose by nearly 17 percent from the previous year. This survey of more than 2,500 colleges and universities in United States found that approximately 4.6 million students were enrolled in at least one online course in the Fall semester of 2008[1].To provide such online courses, the online laboratories are inevitably necessary, especially for the engineering and technology education.

In general, the online laboratories can be categorized in virtual laboratory and remote laboratory[2, 3, 4, 5, 6]. The virtual laboratory is based on software such as LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench), Matlab/Simulink, Java Applet, Flash or other software to simulate the lab environment[7]. Remote experiments use real components or instrumentation at a different location from where they are controlled or conducted. An example of such remote experiments is a model bridge experiment that was conducted and controlled through the Internet or an Intranet[6]. Compared to traditional hands-on experiments, experiments operated remotely over the Internet offer many advantages. One of these benefits is the ability to handle a large number of students to conduct experiments through scheduling. The remote laboratory allows a workaround for complex logistics, such as staff, space, scheduling, budget, and commuting.

Texas Southern University (TSU) is one of the two comprehensive Historically Black Colleges and Universities (HBCU) with more than 9,500 undergraduates and African Americans constitute about 85% of its undergraduate enrollment. The Department of Engineering Technology at TSU offers a Bachelor of Science degree in Electronic Engineering Technology (ELET), Computer Engineering Technology (CMET) and Civil Engineering Technology (CIVT). Over 200 students are currently enrolled in the department. The student population is comprised of about 76% African-Americans, and about 21% Hispanics. Female students constitute 31% of the overall student population in the department.

In order to strengthen the retention of recruited students, and in order to enhance the quality of our instructional effort, we successfully secured the NSF HBCU-UP Targeted Infusion Grant. This grant has facilitated the conduct of a proposed project to be entitled “Development of Virtual and Remote Laboratory for Engineering Technology Undergraduate Students”. A state of the art Virtual and Remote Laboratory (VR-Lab) has been built with partial support from this grant.

In this paper, the project research activities are reported. The student survey results are analyzed and presented.

Virtual and Remote Laboratory Framework

The developed VR-Lab framework is shown in Figure 1. There are two major components in the developed remote laboratory: the scheduler web server and the Remote Experiment Engine (REE). The Scheduler Web Server (SWS) joins a physical laboratory experiment with an Internet end-user by providing account management, authentication as well as users and experiments scheduling. Currently, an entry level web server suffices for the purpose of managing 10 or more classrooms with a continuous use of the related remote experiments. The SWS is written using a combination of open source languages such as PHP (Hypertext Preprocessor) and JavaScript, and hosted on a Linux operating system. The REE allows the experiment to exchange data with the SWS.

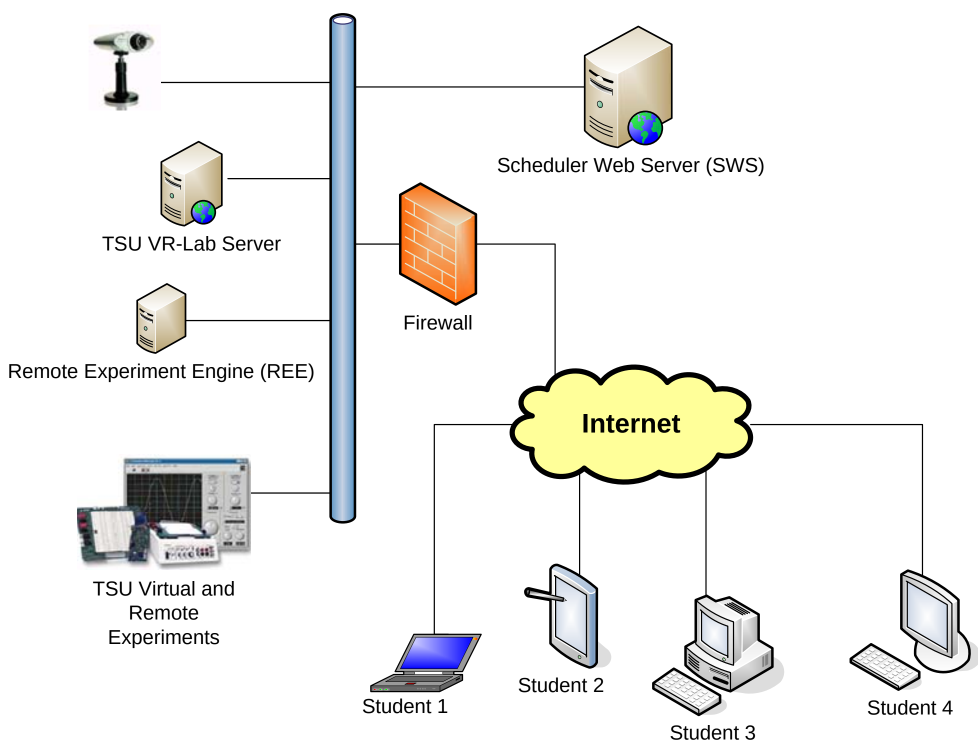

Figure 1 System Block Diagram of the VR-Lab.

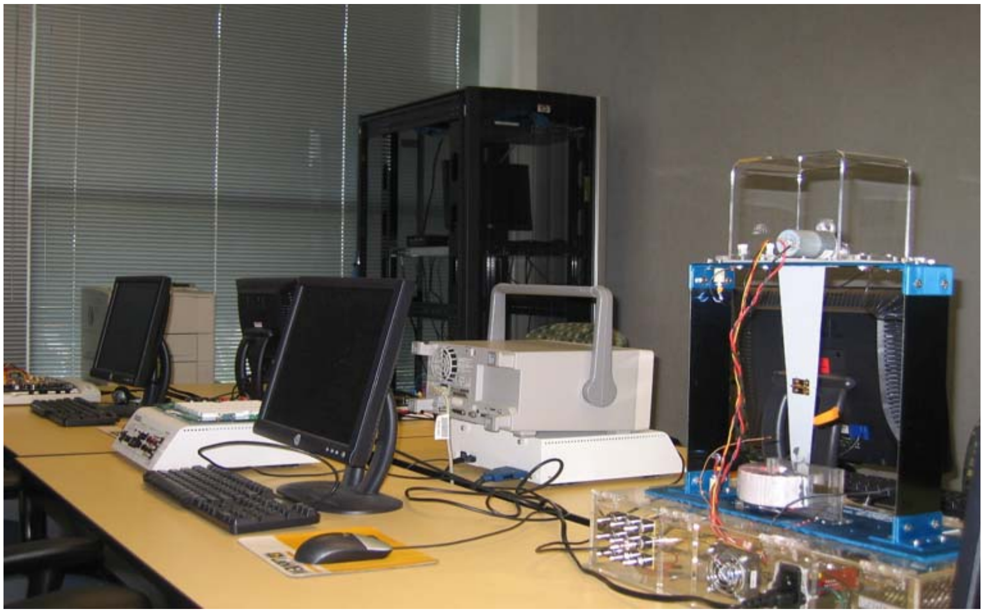

Figure 2 VR-Lab facilities.

In the VR-Lab, a HP ProLiant D360 G6 server is used to host the web server and scheduler web server. A Cisco Catalyst 2960 24 port switch is used to connect to TSU Internet backbone. Several Dell desktop computers are used as remote experiment engines with LabVIEW 8.6 installed. Part of the VR-Lab facilities is shown in Figure 2.

The developed VR-Lab website (http://vr-lab.engineeringtech.tsu.edu/) is shown in Figure 3. And the user authentication interface is shown in Figure 4. When the user logs into the system, he/she can schedule a future time slot with one of the available experiments listed on the web server. At the appointed time, the user will be provided with a customized user interface to connect to the chosen experiment.

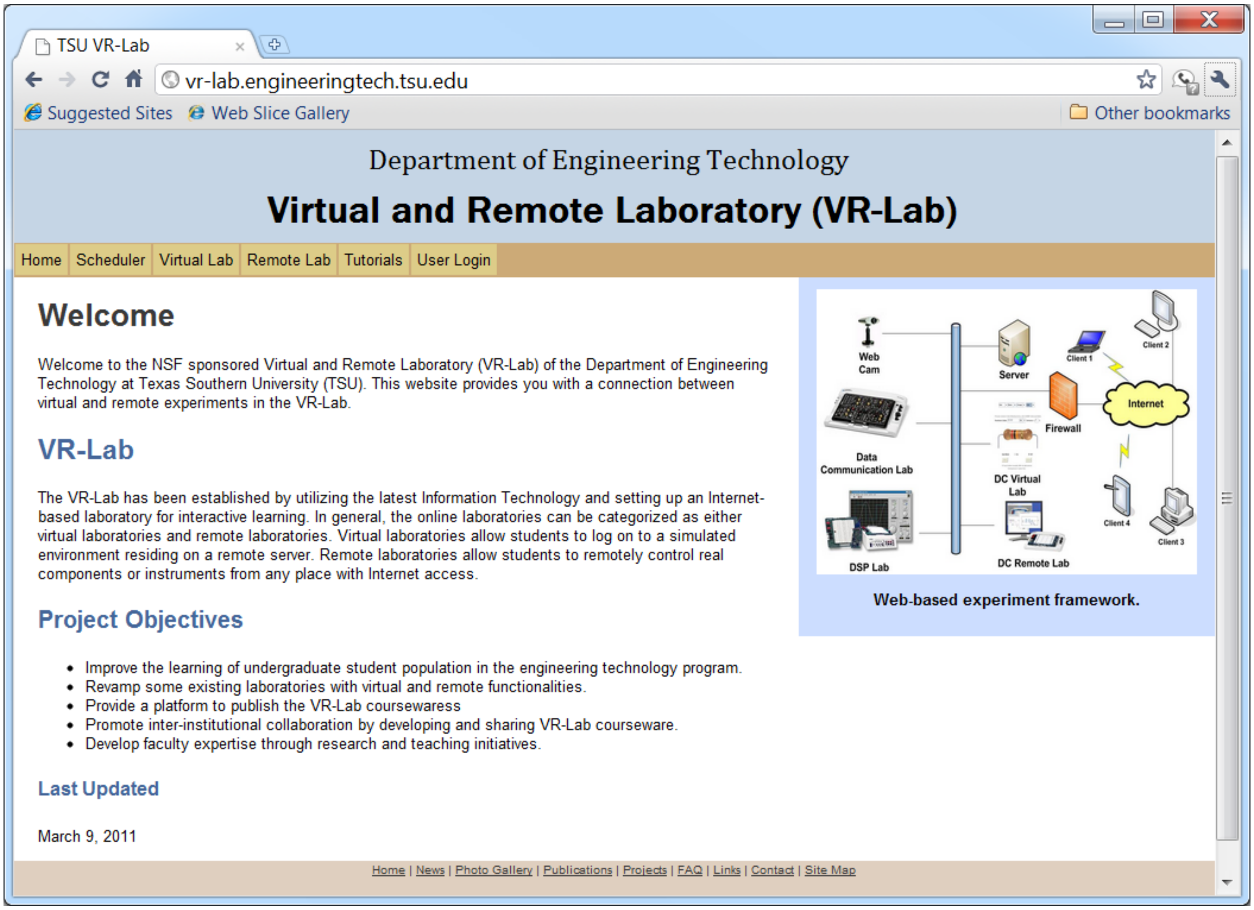

Figure 3 VR-Lab website.

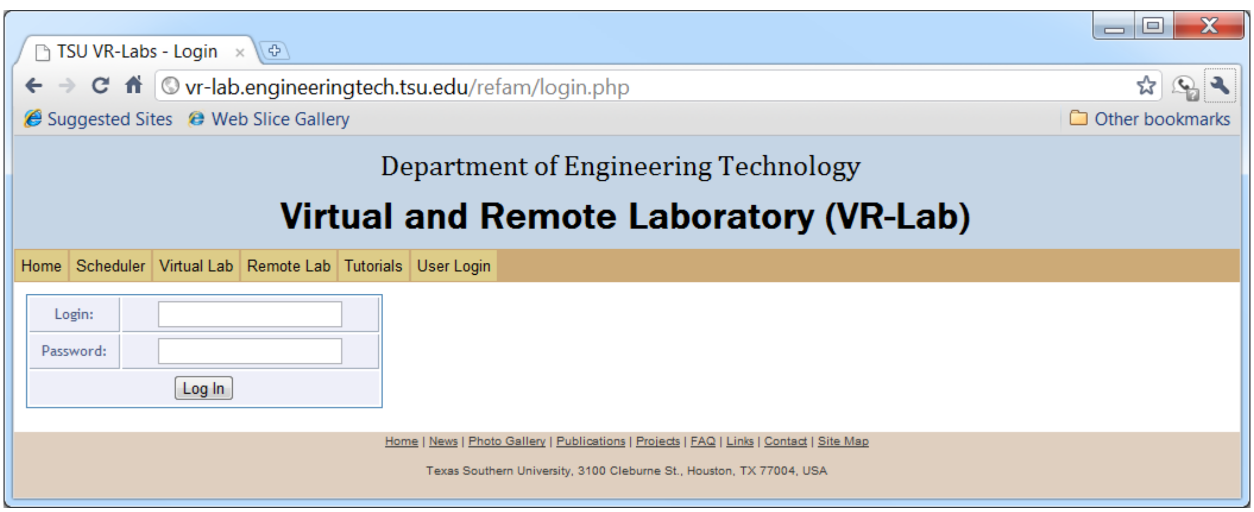

Figure 4 User authentication interface.

MIT iLab Connection

Before developing the VR-Lab framework, a well developed MIT iLab was adopted to teach Electronic I Lab (ELET 112) which helped researchers and students better understand the requirement for the VR-Lab. The Center for Educational Computing Initiatives (CECI) at MIT prepared the microelectronics ilabs and allowed TSU use it at no charge during the life of this grant.

Survey of Students' Acceptability of Remote Experimentation

Students performed three MIT ilab experiments namely:

1. Diode Characterization.
2. NMOS Transistor Characteristics
3. NPN-BJT Characteristics

Students were presented with 15 statements and asked to show their level of agreement or disagreement with each statement by assigning a number between 1 and 5 as follows:

1=I strongly agree
2=I agree
3=I do not know
4=I disagree
5=I strongly disagree

The fifteen statements were:

1. This exercise has been useful
2. Virtual labs can never be as effective as real labs
3. Virtual labs will eventually replace real labs
4. Using the lab was enjoyable
5. The interface is intuitive
6. There aren't enough parameter variations to make this worthwhile
7. Every course should have a few iLabs associated with it
8. Using the lab was **not** intellectually stimulating
9. The lab was slow
10. The interface is confusing
11. I cannot relate this to real life
12. I believe I was actually working with real devices through the internet
13. The lab has no relevance to the coursework
14. Using this lab has made me think about and understand some things I would not have been able just from lectures or textbooks.
15. This lab should be used next year

For now, only 11 students, who had completed Electronic I and are currently taking Electronics 2, were used and we recognize that this number is rather too small for generalization. However, the number is bound to increase dramatically as soon as students come in for the Fall Term.

Table 1 shows the average scores of surveyed students and percentage favorableness.

Table 1Average response score by students

	SURVEY STATEMENTS	AVERAGE RESPONSE SCORE (1-5)	Favorableness Implication of Average Score
1	This exercise has been useful	1.1	98% agree that the exercise has been useful
2	Virtual labs can never be as effective as real labs	2.8	56% feel that virtual labs can be as effective as real labs
3	Virtual labs will eventually replace real labs	2.3	74% believe that virtual labs will eventually replace real labs.
4	Using the labs was very enjoyable	1.4	92% say Using the labs was very enjoyable
5	The interface is very intuitive to use	1.5	90% agree that the interface is very intuitive to use
6	There aren't enough parameter variations to make this worthwhile	3.0	60% feel that there were enough parameter variations to make this ilab experiment worthwhile.
7	Every course should have a few iLabs associated with it	2.0	80% agree that every course should have a few ilabs associated with it
8	Using the lab was **not** intellectually stimulating	3.3	66% feel that the lab was intellectually stimulating
9	The lab was slow	3.5	70% feel that the lab was fast enough
10	The interface is confusing	3.8	76% feel that the interface was clear enough
11	I cannot relate this to real life	3.6	72% can relate this experiment to real life
12	I believe I was actually working with real devices through the internet	2.4	75% believe they were actually working with real devices through the Internet
13	The lab has no relevance to the coursework	3.6	72% feel that the lab has relevance to their coursework
14	Using this lab has made me think about and understand some things I would not have been able to do from just our lectures or textbooks	1.6	88% feel the lab has made them think about and understand some things they would not have been able to from just lectures or textbooks
15	This lab should be used next year	1.3	94% recommend that the iLab be used next year

Figure 5 and Figure 6 show bar charts for these records.

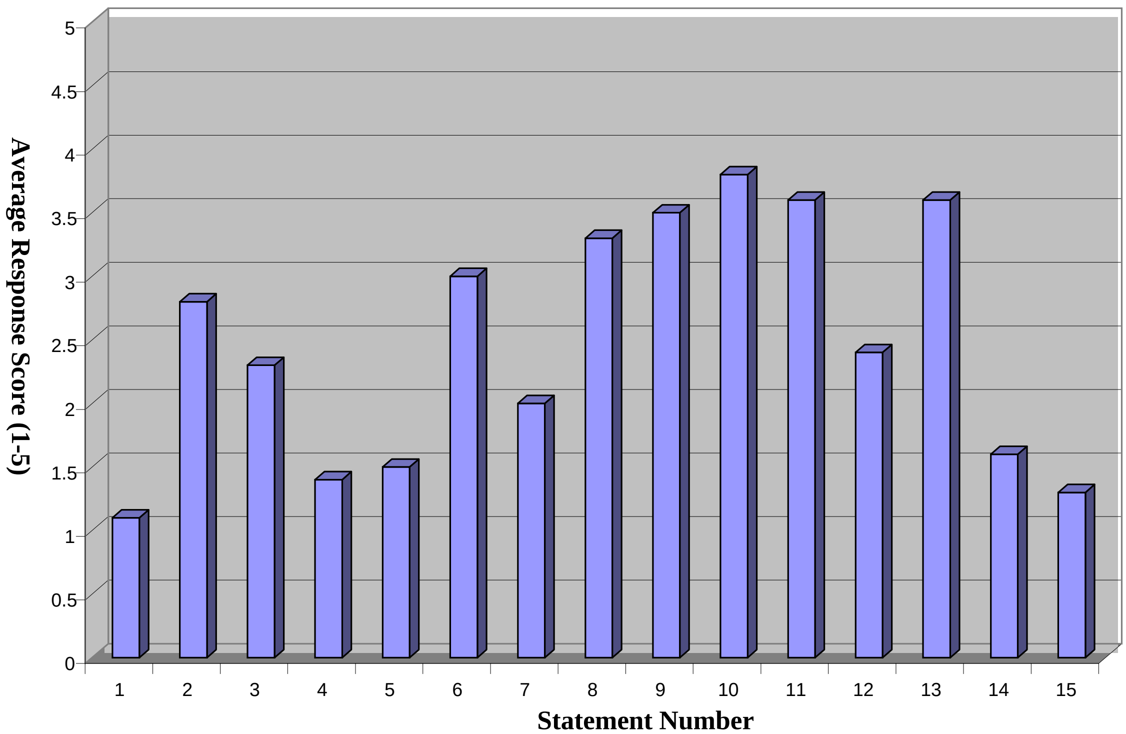

Figure 5 Graph of average response score.

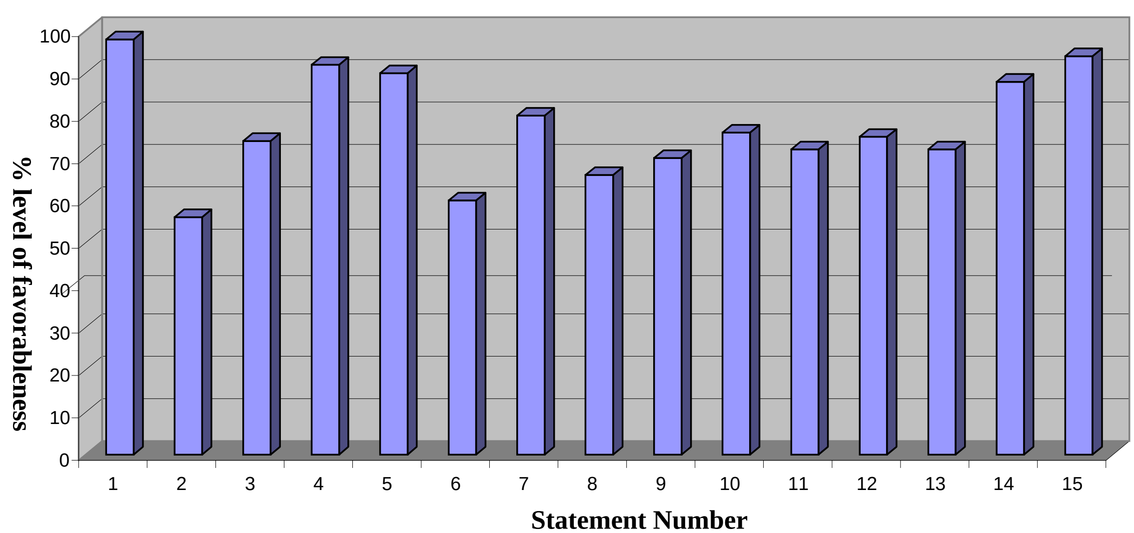

Figure 6 Graph of % level of favorableness.

If we assume the following percentages to represent shown favorability;
80%-100% -Notable Favor
60%-79% -Acceptable Favor
Below 59% -Weak favor

Then the following generalization can be assumed.

1. A great percentage of students felt that:

- the ilab exercise has been useful
- using the labs was very enjoyable
- The interface is very intuitive to use
- the lab has made them think about and understand some things they would not have been able to from just lectures or textbooks.
- recommend that the iLab be used next year.

2. A fairly good number felt that:

- virtual labs will eventually replace real labs.
- the lab was intellectually stimulating
- the lab was fast enough.
- the interface was clear enough.
- they could relate this experiment to real life
- they believed they were actually working with real devices through the Internet.
- the lab had relevance to their coursework

3. A few number of students felt that:

- virtual labs can be as effective as real labs
- there is perhaps enough parameter variations to make this ilab experiment worthwhile.

From these findings, it is obvious that iLab is well favored by most of the students who did the experiment. It should however be noted that because of the small number of students used for this analysis, not much categorical statements can be made. Only the stated trend can be assumed.

Concluded Experiments

During this research, various experiments were designed for dc circuits and data communications. Manual scripts have written for some, while a few were adapted to used one of the recommended texts. They included the following:

1. Ohm's Law.
2. Series Resistance
3. Series Parallel dc Circuits
4. Superposition Theorem.
5. Thevenin's Theorem And Maximun Power Transfer
6. Amplitude Shift Keying (Manual Completed)
7. Frequency Shift Keying (Manual Completed)
8. Time Division Multiplexing
9. Amplitude Modulation.

Conclusion

With the partial support from NSF HUCB-UP grant, a state of the art virtual and remote laboratory has been built. One of the research activates, MIT iLab connection, is reported in this paper. Survey results shows that most of students favored iLab, and felt the lab had made them think about and understand some things they would not have been able to from just lectures or textbooks. This activity successfully helped us to understand the requirement for the VR-Lab.

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