LabVIEW-Based Laboratory for Electronics Engineering Technology Program

Zhaoxian Zhou[1]

Abstract – Distance learning is developing rapidly in recent years due to the development of technology and instructional systems. With the recent budget limits and decreasing in enrollment, distance learning is even more critical. Most of the present distance learning practice is in the fields of liberal arts and science programs, while that in technology programs is much different, because almost all technology degrees require substantial hands-on skills, which are traditionally obtained in laboratory environments. The requirement for hardware laboratories in turn restricts greatly distance learning experience. The Electronics Engineering Technology program in the University of Southern Mississippi is in the process of implementing a project which will provide distance learning through LabVIEW platform. Senior undergraduate students and graduate students took part in developing learning environment; therefore, the project gave them opportunities to develop skills in programming in virtual instrumentation. Users who were usually lower-level undergraduate students improved their experimental skills. This project also aims to enhance the interest in electronics and computer engineering and technology of the high school students in southern Mississippi. This paper provides some details of the project and discusses its effect on student learning outcomes from students' perceptions.

Keywords: LabVIEW, distance learning, virtual laboratory, electronics engineering technology (EET)

INTRODUCTION

Projects and experiments in technical curricula components, such as telecommunications, analog and digital electronics, instrumentation, data and acquisition control, microprocessor control, and robotic control systems, are used to simulate actual job conditions. The projects and experiments provide EET students hands-on experience necessary for entering workplace. The electronics engineering technology program is built around technology, which obviously undergoes rapid change. Frequent curriculum modifications must be implemented to be consistent with the best industry practices, which request a faster and more efficient acquisition of practical skills and knowledge. The technical aspects of the EET program make practical education difficult because technical curricula consists of aforementioned projects and experiments that are bound to a specific time and place. Traditionally, laboratory experiments were handled with breadboard circuits or modular systems. It is found increasingly difficult to provide students with meaningful design experiences using traditional breadboard approaches. In such labs, students spend much time wiring and debugging circuits. Unfortunately, only the simplest circuits are feasible due to time constraints, and student understanding of theory is thus reduced by the necessary focus on getting circuits to work. Modular systems have some distinct advantages over bread-boarding in being able to examine more complex topics. The disadvantages of the modular systems are that they are usually very expensive and specific to only one area. For example, we use Lab-Volt modules in electric power course and TIMS modules in our analog and digital communications courses.

However, due to the present economical situation and sudden reduction in laboratory budget, more hardware investment is difficult. On the contrary, in addition to increasing enrollments, there is a large need for online courses from part-time students. Possible solutions include virtual laboratory and remote laboratory.

---

[1] The University of Southern Mississippi, 118 College Dr. #5106, Hattiesburg, MS 39406 Email: Zhaoxian.zhou@usm.edu

LabVIEW is a commercial program developed by National Instruments (NI), which allows the experimenter to design a data acquisition system using a graphical user interface. It has become the de facto standard of visual programming languages. Significant capabilities have been added to LabVIEW in recent years. There are a great number of libraries of measurements and automation experiments. These libraries were written by educators to show the use of NI products in academic labs around the world. Users use their computers to automate measurements, control instrumentation, design/deploy control systems, signal analysis, data acquisition, motion control, DSP, image acquisition/processing, or perform high-end mathematical calculations in their applications.

The LabVIEW-based laboratory enables students to integrate data acquisition, analysis and presentation with a virtual instrument. Virtual instrumentation can simulate a strip chart recorder, an oscilloscope, a spectrum analyzer, etc. and provide real-time analysis of data. Pedagogically, it provides an ideal learning environment. No experiment can be performed until the student has worked out the details of the experiment, including the methods of data analysis. In addition, the student can make modifications to the experiment while the experiment is progressing based on results from real-time data analysis. Most importantly, it greatly simplifies the process of collecting and analyzing scientific data so the emphasis can be placed on the science rather than the methodology of the experiment. Complex interfacing projects can now be performed in a matter of hours.

REVIEW OF RELATED WORK

There have been numerous LabVIEW applications in literature. To name a few, LabVIEW has applied to integrated design laboratory [1] for lab improvement; a LabVIEW based instrumentation system for a wind-solar hybrid power station [2] for electrical engineering application; in radioactive decay simulation for physics education [3]; for analysis of vibrations from industrial environment [4] for mechanical engineering; position control system with radio telescope [5] for control systems; and digital signal processing [6]. However, most of these applications have been developed by researchers or educators. Student involvement has been limited in the usage of the developed program.

There is a vast of work in literature discussing the differences between traditional, virtual, and remotes laboratories [7, 8, 9, 10]. In both virtual laboratories and remote laboratories, students can login and perform experiments from any place of the world. However, differences exist between the two. For example, remote labs provide extended access to expensive or highly specialized devices, and it has been claimed that unlike simulations remote experiments provide real lab experience [7].

LABVIEW-BASED EXPERIMENTS

The work described in the paper represents an important step towards establishing a LabVIEW-based environment capable of more rapidly transitioning the EET curricula consistent with industry technology changes. In our practice, both instructors and students contribute to the implementation of virtual experiments and projects. Therefore, while the quality of the simulations are guaranteed, undergraduate students and graduate students who have participated in developing the learning environment are given opportunities to develop skills in programming in virtual instrumentation. They will integrate their skills learned from previous lecture courses and lab sessions into a LabVIEW-based software environment.

The developed experiments and projects are used by and demonstrated to undergraduate students, and familiarizes freshman, sophomore, and junior students with specific experiments before they go into the hardware labs to perform them.

Several experiments or projects are illustrated below as examples.

Simulation of Power factor

A LabVIEW simulation is implemented for student to learn the concepts of active power, reactive power, and power factor correction. The front panel of the simulation is plotted in Figure 1.

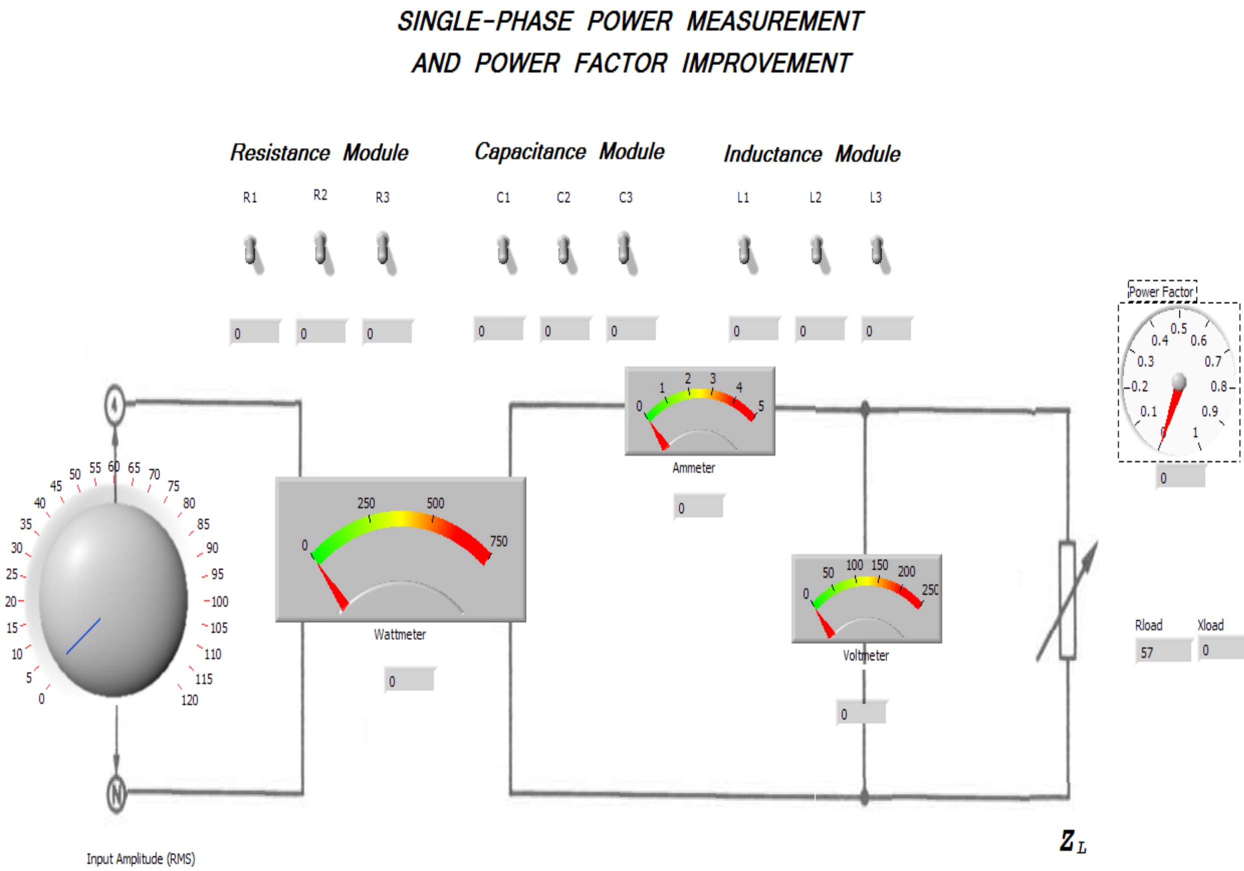

Figure 1: Study of Power Factor

Simulation of Induction Motor

The front panel of the simulation of an induction motor is plotted in the Figure 2. The impedances of the windings are based on measurement in the physical lab.

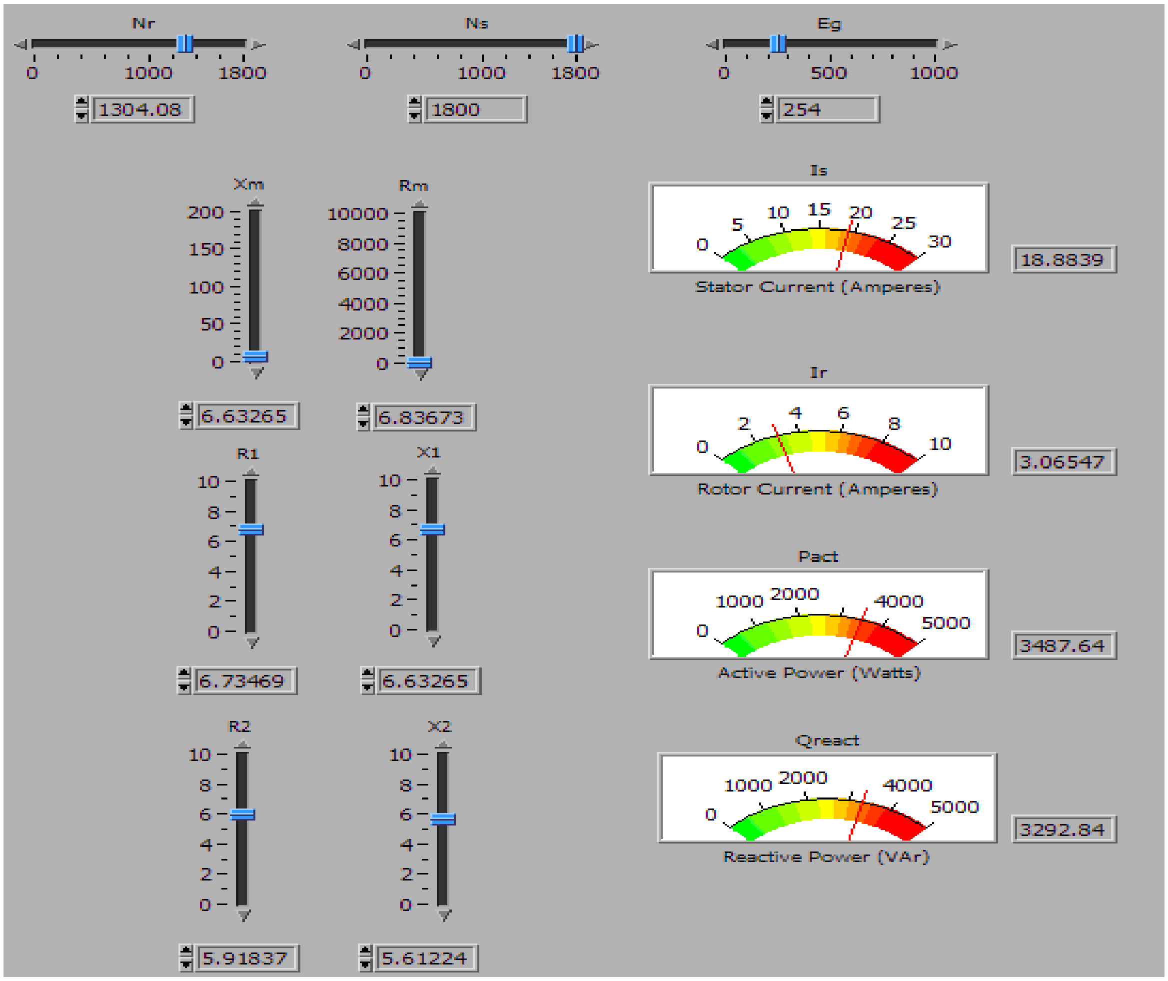

Figure 2: Simulation of Induction motor

LabVIEW Simulation in Senior Project

In a senior project, a student simulated a dynamometer that can be adjusted to work with virtually all types of vehicles (engine types: V4, V6, V8, etc.) with gasoline powered engines that are controlled by a spark timing system. It uses an inductive pick-up clamped around the main coil wire to pick up the pulses emitted. These pulses can be translated into RPM. They first run through an amplifier circuit and then an analog to parallel digital converter. The digital value converted is connected to the NI DAQ board. The project report claimed that "knowing gear ratio and RPM, you can calculate speed. Knowing Speed and RPM, you can approximate acceleration and get an approximation for torque value. Horsepower can be directly calculated from torque."

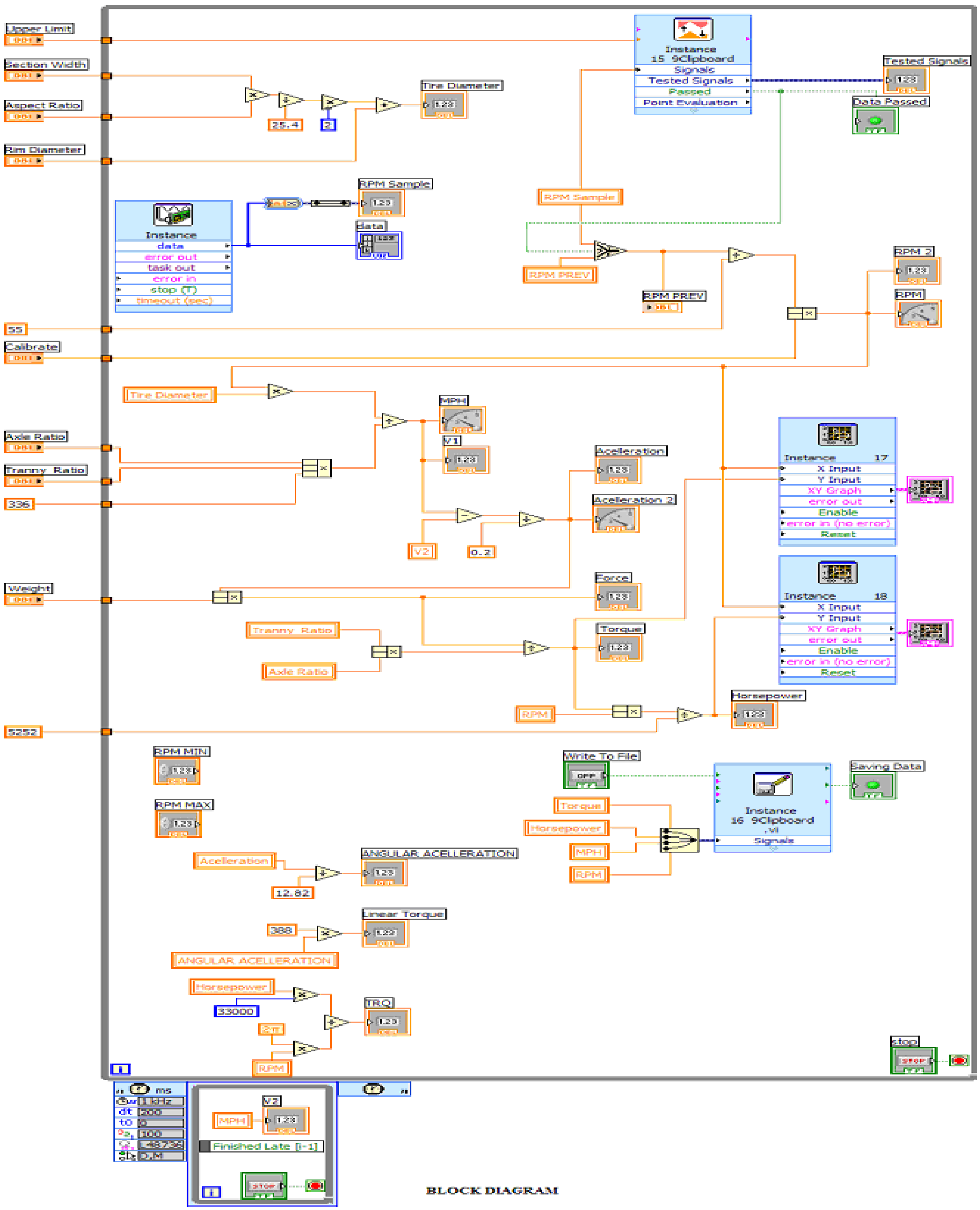

Figure 3: Simulation of a Dynamometer

USER RESPONSES

In our practice, students have been asked to perform both traditional and virtual experiments. An exploratory study has been carried out to investigate the effectiveness of the LabVIEW based virtual laboratories.

Method

There were three experiments in communications class and three experiments in power class from the last two semesters. In some of the experiments students were required to perform the physical experiments or LabVIEW simulation only; in others the students were asked to perform both. The purpose of the arrangement was to obtain a better assessment by students after they were given opportunities to compare each method.

Data Collection

A student survey has been completed recently to evaluate the perceptions of the effectiveness of the virtual laboratory. The survey consists of 20 Likert-type items. Each item has five choice that are scaled as one to five, respectively, representing for “strongly disagree,” “disagree,” “neutral,” “agree,” and “strongly agree”. In addition to the Likert-type questionnaire, there were also several open-ended questions that allowed students to express their comments.

Sample Likert-type questions in the survey are

- Virtual experiments are useful addition to traditional laboratory exercises.
- Virtual experiments can replace the traditional laboratory exercises.
- Virtual experiments are suitable for strengthening knowledge you have already gained.
- Virtual experiments are suitable for gaining new knowledge.
- If virtual experiments are online, you will spend more time studying the labs than you spend on traditional labs.
- Virtual experiments will have better learning results than traditional experiments.
- If you have choice, you prefer virtual experiments than traditional experiments.
- You still want to do the traditional experiments after you performed the virtual one.
- After you performed the virtual experiments, you will be faster to do the physical lab if required.
- If you know some virtual experiments are offered by other universities (other sources), you will try to perform them even you are not required.
- Virtual experiments designed by instructors are better than those designed by your fellow students.
- Virtual experiments setup is the future trend, which means, more and more virtual experiments will be offered.
- Traditional experiments setup is old-fashioned, which will be phased out in the future.
- Suppose we offer online degree in electronics engineering technology, including labs through virtual experiments. You want such an online degree other than the traditional on-site degree.

Sample open-end questions are

- What are the major differences between virtual and physical experiments?
- What suggestions do you have for me if we want to implement virtual experiments?
- Do you want to perform some virtual experiments offered by other universities if not required? Why or why not?
- When you are required to perform virtual experiments offered by other universities, what are your concerns?
- What merits of virtual experiments do you think are important?
- Suppose we offer online degree in electronics engineering technology, including labs through virtual experiments. How do you think the online degree is equivalent to the on-site degree?

Survey Result Analysis

Nineteen feedbacks were collected from the classes, spring and fall semesters, 2009. From the survey we know that 95% of the students have necessary hardware equipment for virtual experiments (e.g., computers with high speed internet connections).

The results for the comparison of traditional and virtual experiments are showed in Table 1. While all of the students agreed or strongly agreed that virtual experiments are useful addition to traditional experiments, only about one third indicated that virtual experiments can replace the traditional experiments and have better learning results. Most of the students surveyed still prefer to do experiments in a traditional laboratory environment.

Table 1: Results on comparison of virtual and traditional experiments

Survey Item	Average Score	Standard deviation	Percent of agreed and strongly agreed
Virtual experiments are useful addition to traditional laboratory exercises	4.16	0.37	100.00
Virtual experiments can replace the traditional laboratory exercises	3.21	0.71	36.84
Virtual experiments will have better learning results than traditional experiments	3.32	0.48	31.58
If you have choice, you prefer virtual experiments than traditional experiments	3.37	0.50	36.84

On the usefulness of virtual experiments, the results are tabulated in Table 2. A large percentage agreed or strongly agreed that virtual experiments are suitable for strengthening knowledge they have already gained; a less number of students said virtual experiments are suitable for gaining new knowledge. Unlike in [11], the two percentages are close, however, the average scores have a larger discrepancy, which indicates that most students agreed, not strongly agreed, that virtual experiments are suitable for gaining new knowledge. Students will get familiar with the subjects from virtual experiments, an advantage that will help them solve practical problems promptly.

Table 2: Results on usefulness of virtual experiments

Survey Item	Average Score	Standard deviation	Percent of agreed and strongly agreed
suitable for strengthening knowledge you have already gained	4.47	0.61	94.74
suitable for gaining new knowledge	4.11	0.57	89.47
After you performed the virtual experiments, you will be faster to do the physical lab if required	4.32	0.67	89.47

Another result obtained from the survey is that, even given a chance, students will be reluctant to do virtual (or remote) experiments that are offered by other institutions, if the task is not required by the instructors. Majors concerns are irrelevancy to the courses they are currently taking, lack of knowledge to perform to simulation, and lack of help in case problems occur, described by students in the open-end survey questions. However, students have showed interest in designing virtual experiments if they are familiar with the language. They said that virtual experiments designed by fellow students are almost as effective as those designed by instructors, in terms of learning outcomes.

The students agreed or strongly agreed (68.42%) that virtual experiments setup is the future trend, which means, more and more virtual experiments will be offered. However, a very small number (21.05%) agreed that traditional experiments setup will be phased out in the future.

SUMMARY

More and more EET programs are offering online degrees. The important laboratory component is handled mainly by family lab kits or virtual simulation. In the paper, we introduced our practice of implementing LabVIEW-based simulation of technical experiments. The purpose of the study is to investigate the perceptions of virtual experiments from students' point of view. Within two semester's period, students and instructors have developed virtual as well as traditional experiments. Student survey results are given after they have carried out both. The survey showed that virtual experiments are helpful in both strengthening old and gaining new knowledge. However, traditional laboratories are still irreplaceable. Even for online degrees, students still prefer traditional face-to-face lab environments. There is still a long way to go if traditional laboratories are to be substituted by virtual laboratories. Virtual laboratories, especially those that aim to a large audience across multi-institutions, should be designed as student-oriented. The author agrees that institutional collaborations and student involvement in the design process are necessary.

REFERENCES

[1] R. K. and etc., "Integrated design laboratory," in 33rd ASEE/IEEE Frontiers in Education Conference, pp. F2E13–F2E18, Nov. 2003.

[2] M. S. Recayi Pecen and A. Zora, "A labview based instrumentation system for a wind-solar hybrid power station," Journal of Industrial Technology 20(3), pp. 1–8, 2004.

[3] I. F. Riad and M. S. El Shazali Elkatim, "A radioactive decay simulation (For Education)," ArXiv Physics e-prints , Dec. 2005.

[4] G. M. a. D. G. I. Lita, D. A. Visan, "Labview application for analysis of mechanical vibrations from industrial environment," in 28th International Spring Seminar on Electronics Technology: Meeting the Challenges of Electronics Technology Progress, May 19-20 2005.

[5] H. A. basher and S. A. Isa, "Labview-based position control system with synchro [radio telescope control application]," in IEEE Proceedings SoutheastCon, 2005, Ari. 8-10 2005.

[6] N. Kehtarnavaz and N. Kim, Digital Signal Processing System-Level Design Using Labview, Newnes, Burlinton, MA, 2005.

[7] Auer, M.E.; Gallent, W.: The "Remote Electronic Lab" as a Part of the Telelearning Concept at the Carinthia Tech Institute, Proceedings of the ICL2000, Villach/Austria, 28./29.09, 2000

[8] Alhalabi,Bassem; Hamza, M. Khalid; Hsu, Sam; and Romance, Nancy, "Virtual Labs VS Remote Labs: Between Myth & Reality", Florida Higher Education consortium Statewide Conference, 1998, ERIC document reproduction Service No. RIE ED 437 026

[9] Heinz-Dietrich Wuttke, Karsten Henke, Nadine Ludwig, "Remote Labs versus Virtual Labs for Teaching Digital System Design", International Conference on Computer Systems and Technologies - *CompSysTech' 2005*, pg. IV 2.1-2.6

[10] Giuliano Donzellini and Domenico Ponta, "The electronic laboratory: traditional, simulated ot remote?" in "Advances on remote laboratories and e-learning experiences", Bilbao, 2007, pg. 223-245

[11] A. Rojko; M. Debevc; and D. Hercog, "Implementation, Effectiveness and Experience With Remote Laboratory in Engineering Education", Organizacija, Volume 42 Issue 1 , pages 23 - 33

Zhaoxian Zhou

Dr. Zhou received the B. Eng. from the University of Science and Technology of China in 1991; M. Eng. from the National University of Singapore in 1999 and the PhD degree from the University of New Mexico in 2005. All degrees are in Electrical Engineering. From 1991 to 1997, he was an Electrical Engineer in China Research Institute of Radiowave Propagation. In the fall of 2005, he joined the School of Computing, the University of Southern

Mississippi as an assistant professor. His research interests include electromagnetics, radiowave propagation, high performance computing and numerical analysis. His teaching interests include face recognition, communications, electromagnetics, antennas and propagation, electric power, and signal processing. He is a senior member of IEEE and a member of ASEE.