

Distance Education: Remote Labs Environment

Bassem Alhalabi¹ M. K. Hamza² Ali Abu-El Humos³

Abstract – Since the invention of the Internet, research for [capable] virtual lab experiments has been the target of higher education’s distance learning research; however, the very nature of real experimentation (real elements and real instrumentation) was not possible or missing from much of the acclaimed virtual lab experiments. Nonetheless, in the past decade or so, countless scholarly writings asserted the availability of [real] or virtual laboratories that mimic real laboratory experimentations. Within these virtual experiments’ infrastructures, the elements of real experimentation- in comparison to conventional laboratories were far distant from constructing real experimentations online. Such a lack of real experimentation-- over the Internet, gave birth to an authentic rise beyond the restrictions of the antiquated virtual laboratories [4-7]. The birth of Remote Labs Environment (RLE) at the Centre of Advanced Distance Education Technologies (CADET), a few years ago, carries with it a world of possibilities and pioneering computing technologies. Therefore, this article conducts a survey of students’ perception of on-line (virtual) labs and in comparison to real labs. The results are analyzed and discussed to put forth an opportunity to learn about a new technology that might change how students conduct experiments, virtually.

Keywords: Remote Labs, Distance Lab Experiment, On-line Experiment perception, Psychology of Learning Online, Engineering Experiments Online, Instructional Psychology

INTRODUCTION

Remote labs Environment (RLE), is a forward step linking software simulation to real physical labs. While software simulation is limited by design and outcome, RLE experimentation can take place in actual physical labs rather than a simulated environment (e.g. conducting a physics experiment using a computer software with animated and controlled set of modules and instructions). At times and as needed, RLE can be effective substitutes for conventional labs (campus labs)-- especially if the following advantages are being sought: cost reductions in terms of labs maintenance, student safety, and ample flexibility that may provide people with disability the comfort of experimenting online with real physical setups and without having to leave their homes. In order to build a RLE experiment, specific hardware and software setup is required (see Figure 1). For example, a typical remote lab experiment might include the following basic components or building blocks:

¹ Department of Computer Science and Engineering, Florida Atlantic University, 777 Glades Rd., Boca Raton Florida, 33431, alhalabi@fau.edu.

² Professional Pedagogy & Educational Technology Leadership, Lamar University, Texas, hamzamk@my.lamar.edu.

³ Department of Computer Science, Jackson State University, 1400 Lynch St, Jackson Mississippi 39217, ali.a.humos@jsums.edu.

- **Range of sensors:** a mixture of sensors to read and measure the experiment variables from the various points of the experiment setup, such as digital potentiometers, temperature, pressure, motion, acceleration, force, compass, GPS, or others—based on the prototype of specification.
- **Range of actuators:** a mixture of actuators to control and manipulate the experiment's parameters and control points, such as motors, solenoids, heating element, switches, etc.

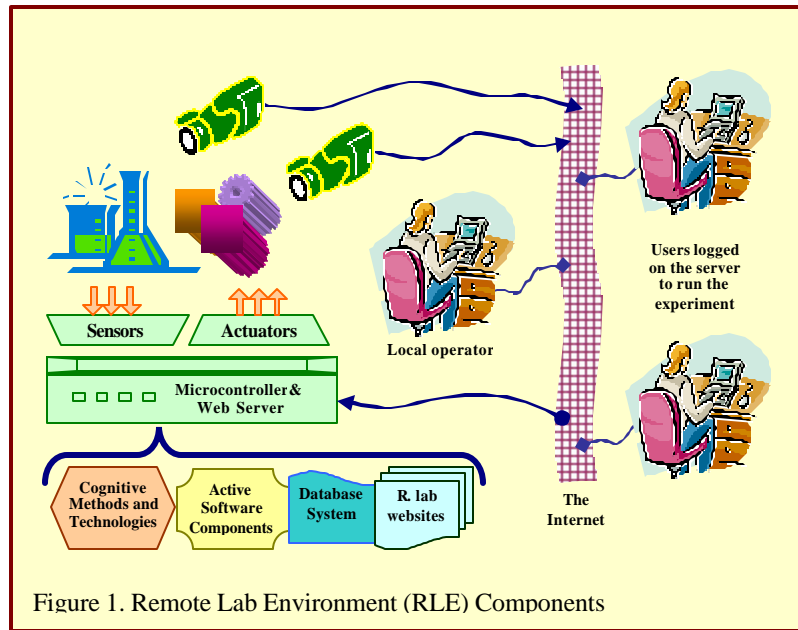


Figure 1. Remote Lab Environment (RLE) Components

- **Data acquisition & control unit (DAQ):** an interface between the sensors and actuators, other instrument devices and computer-server(s). This module's chief functionality is to communicate the computer commands to actuators as well as communicate the data measurements to the computer.
- **Computer (microcontroller):** this component basically runs the experiment software and goes through the experiment steps and interacts with the user via the DAQ and sensors/actuators. Many controllers are available in the market. The National Instrument Data Acquisition boards, BASIC Stamp Microcontroller from Parallax Inc., PIC microcontrollers and the like. Hardware and software components in addition to other hardware platforms are used to build remote labs infrastructures-- at CADET.
- **Web server:** the web server(s) are connected to a set of microcontrollers controlling different experiments. This component hosts the login web pages and runs the GUI's where student log in and access the microcontroller software. Lately, an embedded web server with a microcontroller and DAQ functions are included in one chip—e.g. of such a single-chip web server/microcontroller is the Freescale MC9S12NE64 [3].
- **Web camera:** a web camera is used for video transmission. The web camera is located in a lab to help users/students visually see the experiment via the Internet from any location on this planet. Web cams are usually connected directly to a dedicated LAN.
- **Database:** layers of software components-- residing on the web server—make a database system that serves as a tool to authenticate users and secure online communications. The database system ranges from a complicated robust information system (e.g. ORACLE) to a simple and easy to use system, such as MS Access, which have been used in most of the constructed online experiments.
- **Chats & Discussions:** Chat rooms are created to enable students to interact with each other to negotiate meaning of subject matter. Also, for students to interact with their instructors and teacher assistants. Chat rooms are audio/video capable and are an integral part of the overall remote lab setup.

In summary, RLE is a possibility and a new opportunity for people in the diverse fields of education, technology, and information systems. An authentic and well-guided research in this area will lead into a promising advancement for better learning and teaching at a distance. A survey was conducted to assess

students' attitudes toward this new technology in comparison to conventional labs and software simulations. Data analysis and findings of the survey is discussed in this paper to further explore the efficacy of this new technology and the impact of existing lab technologies.

DISTANCE LEARNING SURVEY

This survey was conducted at FAU. Students from different colleges, different majors, and different educational levels were asked if they wish (voluntarily) to be part of this study. In this survey, RLE (or RL) was compared against Software Simulation (SS) and against Campus Labs (CL)—conventional labs. Sets of questions were analyzed in segments—as statistical modules for reliability and validity purposes.

Segment 1- Questions Set 1	Result (%)
When performing an experiment I prefer to use RL.	72.5
When performing an experiment, I prefer to use SS.	70
When performing an experiment, I prefer to be physically present in the CL.	80

This segment's results illustrate that students have almost an equal interest in doing their labs experiment via remote labs or via software simulation. Less interest in performing lab experiments via software simulation may be justified due to the fact that software simulation won't as real of a representation (experiment) as is the case in remote labs. Favoring to use lab experiments in a real physical lab may be justified by the following facts:

- Neither remote labs nor software simulation may replace the physical lab experience—yet!
- The technologies used to develop remote labs require more improvements to enable the students to get the same experience—and same learning satisfaction, they may obtain had they used real experiments in a real physical lab

Segment 2- Questions Set 2	Result (%)
Using RL has stimulated my interest in this area of study.	60
Using SS has stimulated my interest in this area of study.	60
Using CL has stimulated my interest in this area of study.	70

For students to respond accurately to this question, RLE was explained and discussed with students. Then RLE experiments were conducted for students before students were able to try the experiments on their own. For examples, one of the experiments was a basic electrical test where the student login to the RLE experiment website and then he or she applies different current values through a resistor. The student then reads the corresponding generated voltages across a resistor terminal. After conducting this experiment and from the results of this segment, the preference of real physical labs is apparent. On the other hand, this question raised another imperative question: what are the applications in which remote labs might better serve the students and the learning process over both: software simulation and conventional labs?

Segment 3- Questions Set 3	Result (%)
Performing the experiment via RL has facilitated in learning the material.	70
Performing the experiment via SS has facilitated in learning the material	70
Performing the experiment via on CL has facilitated in learning the material	80

The equity between remote labs and software simulation reflects the fact that remote labs need more enhancements in terms of the hardware and software used to develop the remote labs environment should the remote labs be able to relinquish software simulation and be at the same time a substitute for real physical labs.

Segment 4- Questions Set 4	Result (%)
The experiments procedures and purpose was clearly understood using RL.	75
The experiments procedures and purpose was clearly understood using SS.	67.5
The experiments procedures and purpose was clearly understood using on CL.	85

The results of this segment of questions illustrate a preference for RLE over software simulation. This, however, can be justified by the precise design of RLE software documentation and instructions. On the other hand, software simulation is still a trial of fitting the experiment variables into a close-system of programmed variables, constraints, and affordances as created by the programmer(s).

Segment 5- Questions Set 5	Result (%)
Performing the experiment via RL has helped in understanding the theory/concept underlying the experiment.	75
Performing the experiment via SS has helped in understanding the theory/concept underlying the experiment.	70
Performing the experiment via on CL has helped in understanding the theory/concept underlying the experiment.	85

In this segment of results, once again; conventional labs demonstrate overall preference by students. Remote labs illustrate a step closer to conventional labs' preference than software simulation due to its proximity to reality- more so than software simulation.

Figure 2 shows that 57% of the students like to take online courses with on campus labs, where 31% prefer online courses with remote labs and only 12% of the students prefer online courses with software simulation experiments. Most of the students justified their choice claiming that such online course with remote labs are not available on the schools all over the U.S. They also opposed the remote labs concept because they believe that lab courses can't be taught effectively online, they need face-to-face interaction.

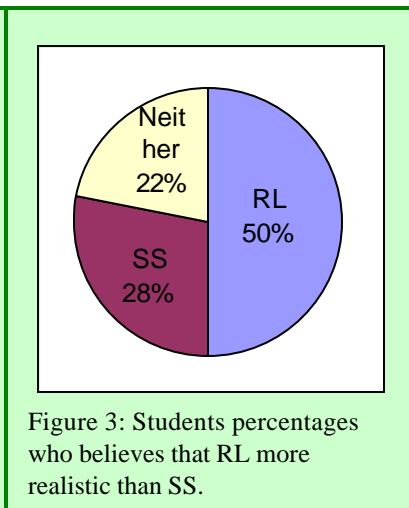
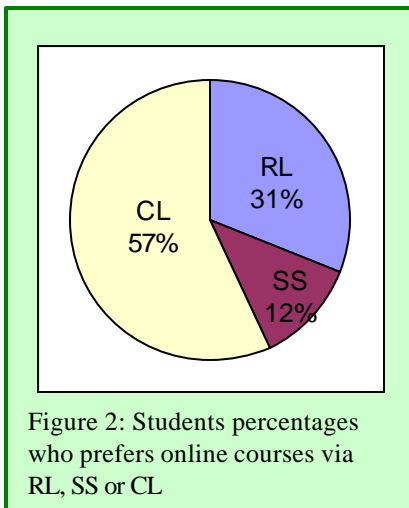


Figure.3 shows that most of the students are convinced that remote labs environment is more realistic than software simulation. Others would say that neither remote labs environment nor software simulation will be as realistic as the physical on campus labs.

QUALITATIVE FINDING

The following is some of the feedback students made about RLE:

- “This technology is relatively new for me. Though I haven't had much experience with RLE I found the experiments to be extremely interesting.”
- “The only problem with doing experiments outside the classroom is the lack of the teacher and students. Both are needed for answering questions and demonstrating. As we all know only a few experiments go correctly the first time. Often student have no idea, what went wrong. A live chat room should be incorporated for those who have questions.”
- “Use of RLE depends on its applications but not for all experiments.”
- “A very important part of understanding the lab is the teacher, TA or the instruction book. If any of these are lacking, it doesn't matter, weather RL, SS or CL.”
- “Manipulating real lab objects is more benefiting than clicking mouse buttons.”
- “RLE is a good idea, good experiments; but I feel that real hands on experience are more important.”
- “It would be nice to have more experiments to base our comments on.”
- “If the online course plus software simulation can offer the real time help, then it could be perfect.”

The authors found the feedback to be to some extent essential to the survey findings, however, due to the small number of responses, the quantitative results seem to outweigh the qualitative results in understanding students' attitudes and opinions.

REMOTE LABS EXPERIMENTS

The following is description of some remote labs experiments that were built at CADET:

I. Active Element (Transistor) Characterization Experiment

Using this experiment setup, students can login to the experiment to discover the IV (Current-Voltage) characteristics of an unknown transistor. The microcontroller block is based on the Freescale Semiconductor MC9S12NE64 [3], which is a microcontroller and web server at the same time. It also has built-in 8-channel analog-to-digital converter and general purpose I/Os. This web server hosts an embedded webpage with all necessary ActiveX controls which control the experiment's sensors and parameters. The software layer interface was designed using Microsoft Visual Studio 6.0.

When student logs into the site, GUI software instructs him to adjust the transistor base current and apply a voltage sweep function on the collector. The controller then reads the voltages and corresponding currents of the transistor and save them in an access file. Data is then drawn in an excel chart. The full description of this experiment is furnished in [1,2], and the actual experiment could be tried on line following this link: <http://activeelement.cse.fau.edu>.

II. Measuring Static and Kinetic Friction on an Inclined Plane

The aim of this experiment is to determine the coefficients of static and kinetic friction between a given block and a surface. A block (of known mass M) is positioned on an inclined plane whose inclination can be changed by a drive from stepper motor A. The angle of the incline (θ) is measured using a remote camera and a protractor. The block is attached to a second stepper motor (B) by a thread that is attached to a force sensor located on the block.

To measure the static friction, the block is left free on the incline, and the angle is gradually increased until the block starts sliding. The coefficient of kinetic friction is determined by pulling the block up the slope at constant speed after its initial breakaway. With these parameter, speed, incline angel, force, mass, various experiment could be conducted. The details of this experiment are furnished in [4-7].

CONCLUSION

RLE technology is a new modality for many students as well many academicians. It is a promising learning tool for future distance education applications—especially science and engineering experimentation. Based on this survey, which is limited to the number of students and number of questions asked, students seem to prefer online courses while still using physical lab (conventional labs) rather than online courses using other modalities (software simulations or RLE). While remote labs may never replace conventional labs, fully and at least for now, but it can be a very efficient modality of distance learning and an embedded design that compliments both conventional labs and remote labs. For example based on the results from the survey, 80% of the students indicated that they prefer to use conventional labs while 72.5% indicated they would use RLE. It is important, also, to note that there are a higher percentage of students who prefer conventional labs to any other modality (see figure 2). Nevertheless, when comparing RLE and SS, we detect higher percentage of students that would rather use remote labs than SS (see Figure 3). Some of advantages that remote labs might have over conventional labs are: safety-- especially working on a hazardous chemistry experiment or attempting to manage complex laboratory experiments. In addition, a large numbers of students can use RLE at the same time for multitask and multipurpose assignments, anytime, any place.

This assertion is made based on a survey's finding: the correlation analysis which aimed at examining the relationship between students' preferences to which modality (RLE, SS, or CL) they would like to use and why. The correlation between student's preference and their selection of remote lab was found to be significant ($r = 0.764$). This correlation significance indicates that there is a strong positive [linear] relationship between the two examined variables. The students have stated that the experiment via RLE has helped them in understanding the theory and concepts (concrete and defined) of the experiments. It might be interesting; however, to further explore the correlation between the response variable and all the independent variables considered in the study. The authors might investigate such a complex correlation in a future inquiry.

Moreover, a chi-square test was conducted to test if there any significant difference in the proportion difference of students choice to what they want use; the results was: a [Chi-square test of 383.6], and [p-value of 0.00], which indicates that there is a statistically significant evidence that the proportions of students who prefer to use CL, RL, and SS are different at alpha 0.05 level of significance. Hence, it is the authors' assumption that further examination of all variables and their correlation significance and relationships must be explored with a larger random sample size of students.

For further research, one may target the following points:

- 1) Possible ways to encourage students to use remote lab;
- 2) Is there any gender preference to using online remote lab;
- 3) Are there any significant relationship between student performance taking online courses via remote labs and those taking courses using campus labs;
- 4) Use more powerful statistical techniques such as [logistic regression] and [discriminate analysis] to study the relationship between students preferences to a specific communication modality (Online/RLE, Online/SS, and CL) versus several set of explanatory variables such as gender, and students performance in the courses;
- 5) Use a larger sample size and more representative sample of students who have more online experience may reveal more significant results, higher percentage of student's preferences to use remote lab; and finally

One must attain that as online distance education continues to improve and develop there will a continuous need for research development; a statistical analysis and updated technology for remote lab to be able compete with the conventional labs. This is a step forward that might help us explore a new way of teaching and learning at a distance and with objective quality assurance [7-14].

REFERENCES

- [1] Humos, A., Alhalabi, B., Hamza, M. K., Shufro, E., & Awada, W., "Remote Labs Environments (RLE): A Constructivist Online Experimentation in Science, Engineering, and Information Technology", the 31st Annual Conference of the IEEE Industrial Electronics Society Sheraton Capital Center, Raleigh, North Carolina, USA November 6 – 10, 2005
- [2] Humos, A. M. (December 2002). "Remote Labs: Active Element IV Characteristics": A thesis submitted to the faculty of the College of engineering at Florida Atlantic University.
- [3] <http://www.freescale.com>
- [4] Alhalabi, B., Jordan, R., Abu-El Humos, A., & Hamza, M. K., "Measuring Static and Kinetic Friction on an Inclined Plane via Remote Labs Modality", the World Multi-Conference on Systemics, Cybernetics, and Informatics SCI 2005. Orlando, FL.
- [5] Alhalabi, B., M. K. Hamza, and Marcovitz, D. M. (2001). "Innovative distance education technologies: remote labs in science & engineering education". *Journal of Online Learning*, 12 (1).
- [6] Hamza, M. K., & Alhalabi, B. (1999). Virtual education: reality or virtuality? Published conference paper. Association for the Advancement of Computing in Education (AACE), Society for Information Technology and Teacher Education (SITE) 1999, San Antonio, TX.
- [7] Hamza, M. K., Alhalabi, B., Jordan, R., Yaseen, N., Shukla, S., & Abu-El Humos (2005). Remote lab environments (RLE): real experiments at a distance in science and engineering. 3rd International Conference on Computer Science and its Applications (ICCSA-2005). San Diego, CA.
- [8] Giller, D, Salzman, C and Gorrochategui, E. 2000. "Remote Manipulation with LabVIEW for Educational Purposes". Swiss Federal Inst. of Tech. Lausanne (EPFL), Website: http://www.ni.com/academic/distance_learning.htm.
- [9] Hesselink, L., Rizal, D. and Bjornson, E. (2000). "CyberLab, A New Paradigm in Distance Learning". Stanford University. Web site: cyberlab.stanford.edu
- [10] Yapura, C., Griffin, R. and Lagoudas, D. (2000), "Mechanics of Materials Experiments Via the Internet". Texas A&M University.
- [11] Bagnasco, A, Chirico, M., Michelis, W, Rossi, A and Scapolla. (2000). "Electronic Instrumentation Laboratories on the Net". Dept. of Biophys. & Electronic Eng., Univ. of Genoa,.
- [12] Hellman, J. A. (2003). Distance Education Its Advantages and Shortcomings. UN Chronicle Online Edition-World Summit on the Information Technology
- [13] The Princeton Review (2004) <http://www.princetonreview.com/>
- [14] Gagné, Ellen; Yekovich, Carol Walker; and Yekovich, Frank R., (1993). *The Cognitive Psychology of School Learning*. Longman: New York.

Dr. Bassem Alhalabi

Associate Professor at the Computer Science and Engineering Department, and Director of the Center for the Advancement of Distance Education Technologies. Florida Atlantic University. 777 Glades Road, Boca Raton, Florida 33431. Tel: (561) 297-3182, email alhalabi@fau.edu. Dr. Alhalabi has a PhD and an MS in computer engineering, and an MS and a BS in electrical engineering. His main area of research and teaching is embedded, mobile, and web-based control systems. He has 50+ publications and a member of 8 professional organizations including IEEE. He owns a patent and others pending. He has been recognized by 6 honor societies including Tau Beta Pi, and received 13 academic awards including FAU Most

Outstanding Professor. He was included in “Outstanding People of the 20th Century”, 1999, the International Biographical Center of Cambridge, England.

Dr. Khalid Hamza

Associate Professor in the College of Education & Human Development teaching psychology of learning as well as technology leadership management courses at the graduate level. Dr. Hamza earned his Ph.D in Educational Psychology Foundations from Texas A & M, College Station, TX and his post graduate education in computer science, psychology, and instructional technology. His areas of specializations are in cognition and instruction, computing sciences, distance learning, remote labs, and management of information systems. He earned numerous prestigious awards and published extensively in areas of specializations.

Dr. Ali Abu-El Humos

Assistant Professor at the Computer Science Department at Jackson State University. Dr. Abu-El Humos received his B.Sc degree in Electrical Engineering from the University of Jordan in 2000. He joined Florida Atlantic University in August 2000 where he received his Masters and Ph.D degrees in Computer Engineering in 2002 and 2005 respectively. Dr. Abu-El Humos research interests include Medium Access Control Protocols for Wireless Sensor Networks, Remote Sensing and Control and Web technologies.