CYBERLAB, REMOTE VIRTUAL EDUCATIONAL LABORATORY

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ABSTRACT

Online learning is in its infancy, but is developing rapidly on a global scale. The shift from the classroom to online can be described as a shift from “efficiency to quality”. [10] High quality online teaching is not just a matter of transferring class notes or a videotaped lecture to the internet; new paradigms of online learning which include both the process and content are needed.

In this paper, we discuss the design and development of interactive online learning materials that enables the virtual replication of the learning of both the process and content of electronic laboratory - CyberLAB, Remote Virtual Educational Laboratory. CyberLAB refers to a representation of the laboratory that is distributed on the network and provides access to and control of the real laboratory instrumentation and experiences. The CyberLAB not only provides interactive animation but adopted the high level simulation technique in designing the virtual instrument. The design refined to every details behavior of the instrument to achieve the real experiences and authentic learning environment. To avoid moving the experimental setup to the classroom or to overcome the difficulties of accessing laboratories facilities at any time, CyberLAB allows students to explore and conduct real-time experiments over the internet. This online facilities helps developed our students to be an independent learner, allowing them to take charge of their own learning. CyberLAB allows students to immerse themselves into the virtual laboratory experience allowing the chance to practice, reflect, and implement new approaches based on feedback and learned content.

KEYWORDS

Remote, virtual laboratory, simulation learning, online experiment

Introduction

Online learning is in its infancy, but is developing rapidly on a global scale. High quality online teaching is not just a matter of transferring class notes or a videotaped lecture to the internet; new paradigms of online learning which include both the process and content are needed and are being explored. Lecturers and students are now looking forward to new e-learning (online learning) experiences for different reasons [1]. While lecturers gain time for higher level teaching by moving the knowledge acquisition of basics into self learning activities, students like the flexibility for time planning reasons.

On the other hand, the traditional laboratory teaching programs are costly and the high-cost instruments could only be shared by a limited number of students at one time, at times limiting the effectiveness of the learning process. Thus, there is much potential and benefits in leveraging on technology to create an online virtual laboratory environment.

However, a key component of current online learning implementation is missing – online practical learning or laboratory experimentation. In engineering education, written exercises are necessary for a student to master mathematical tools while virtual experimentation done by simulation serves to reinforce the understanding of the subject. In engineering, real experiments are indispensable for developing skills to deal with instrumentation and physical processes, while, practical projects provide the framework for a group of students to learn to cope with real world problems. There is no doubt that nothing will replace synchronous learning through face-to-face interaction and physical hands-on experiences but it is not always feasible for students to attend conventional classes. Thus, the design of online learning materials is not meant to replace for face-to-face sessions but rather as a complement (and at times a supplement) to facilitate all related learning and teaching experiences.

Hence, the team's challenge was to ensure that what the students experience online is identical to the actual experiment. The online practical learning has to be designed such that it allows the students to immerse themselves into the virtual laboratory experience, allowing them the opportunity to practice, reflect and implement new approaches based on feedback and learned content.

System Planning and Design

The advances made by Information Technology has led to some learning processes being replicated to varying degrees in the form of courseware available through the Internet, thereby providing flexibility and convenience as well as overcoming some traditional barriers such as time and space. Leveraging on web-based learning systems, the team decided to integrate the concept of virtual instrumentation and the concept of an e-Learning community to address the challenge.

The team developed the CyberLAB system which is designed in an interactive web-based environment consisting of virtual instruments and guided experiments on basic circuits to create a virtual laboratory. The strategies used in designing the system were based on the essential characteristics of the change in the learning process as learning progresses [2]. It is important to match resources and support to the appropriate stage. Hence, the architecture of the CyberLAB system is designed in three stages, describing the transition from novice to expert performance – conceptualisation, construction and dialogue [2].

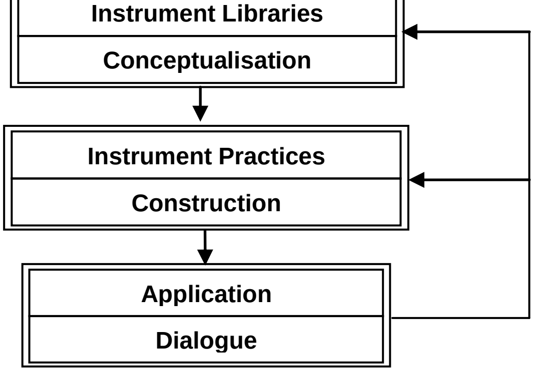

Figure 1. Learning cycle used in CyberLAB system

The first section of the CyberLAB system – **'**Instrument Libraries**',** consists of a series of simulated instruments that are commonly used in the laboratory. The purpose of this section is to present the instruments in interactive activities for students to explore and build concepts. This involves an interaction between the students' pre-existing framework of understanding and a new exposition.

Figure 2. User Interface Design for the 'Instrument Library'

To allow the process of building and combining concepts through the use in the performance of meaningful task, the second section of the CyberLAB system was developed into a series of 'Instrument Practices**'** that consist of the combination of more than one instrument. By designing a specific practice, the system allows the student to combine the concepts grasped in the earlier section of 'Instrument Library' and to reinforce their understanding of each instrument. The instructional design of this section follows closely on the cognitive scaffolding and experiential learning.

Figure 3. User Interface Design for 'Instrument Practices' - Function Generator & Oscilloscope

As a complete learning cycle, the conceptualisations built in the first section are tested and further developed in the last section of the CyberLAB system – **'**Application**'**. This section was designed as a situated learning or task-based learning activity through the online experimentation. The defining characteristic of this section is the 'combining' of the learning experiences and self reflection.

Figure 4. User interface design for the 'Application' - Experiment setup for Inverting Amplifier

The development of the instrument libraries and practices is based on the simulation technology. The process of development of each instrument involved: familiarisation of the instrument, studying every detailed function and behaviour of the instrument, modelling the instrument into mathematical models and graphical representations. The result is an integration of the simulated instrument into a learning framework.

Hardware Setup of Remote Online Experiment

The hardware setup of the system is illustrated in the block diagram shown in Figure 5. The experiment circuit was connected on the analogue and digital logic trainer. The input signal to the experiment was generated from the function generator and the output signal from the experiment was measured using the oscilloscope. Both instruments were connected to the GPIB (General Purpose Interface Bus) controller to allow the access and control thru the PC system. The relay/ DIO (Digital Input and Output) controller is used to control the circuit connection.

Compared with simulated experiment in virtual reality, remote manipulation on real processes is easier to implement and more versatile. In fact, adding another instruments hardware in the system does not involve the elaboration of complex mathematical models and graphical representations.

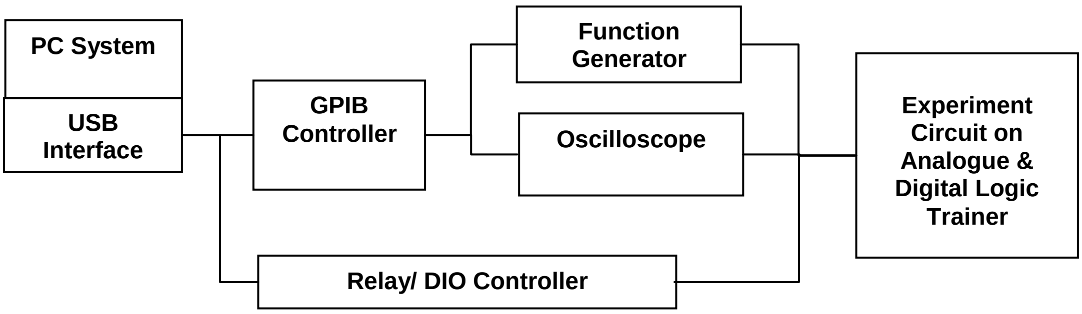

Figure 5. The block diagram of the system hardware setup

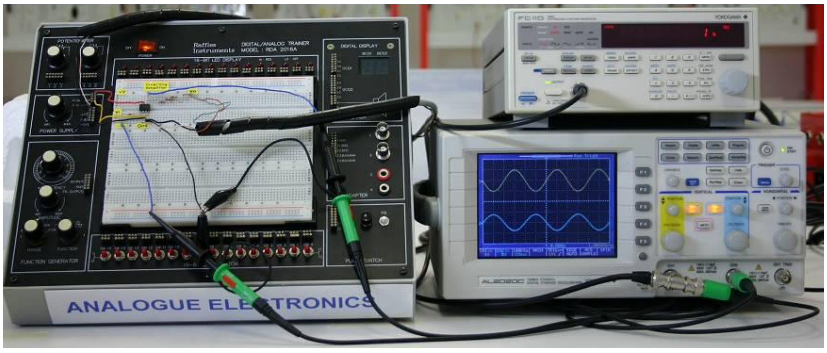

Figure 6. System Setup

Benefits of the System

The key benefit of the CyberLAB system is to leverage on simulation technology to increase students' engagement in practical learning. With the pedagogy in place, CyberLAB has enabled students to explore and conduct experiments over the internet and to have an advanced understanding on the concepts of experiments and how to operate the equipment even before the actual hands-on session [3].

CyberLAB has helped to shorten the learning time required in the laboratory. The students' advanced understanding on the concepts of experiments and the operation of the equipment has helped to reduce potential damage to lab equipment by new students as it would be easier for them to recognise the knobs and buttons on the front panel once they have used the virtual system. It has also facilitated revision for students to further reinforce the understanding of the experiment. It has provided an opportunity for on-demand experiments which enables the students, especially the slow learners, to repeat their experiments.

This online facility has helped developed our students to be independent learners to take charge of their own practical learning, thus cultivating a life-long learning habit. CyberLAB has indeed enabled students to immerse themselves into the virtual laboratory experience, allowing them the chance to explore and conduct experiments over the internet and to practice, reflect, and implement new approaches based on feedback and learned content.

Staff have also benefitted from the use of CyberLAB as it has enabled them to devote more time to the weaker students as well as provide more challenging experiments for the better ones. With the remote online feature of CyberLAB, staff could also access it and conduct live demonstrations in the classroom when necessary.

With CyberLAB, high-cost instruments are now being able to be 'shared' by many students which would substantially reduce the cost of training instruments and increase the utilisation rate of instruments.

Evaluation Results

The evaluation of the CyberLAB has been focused on the course design and course delivery workflows. [9] The evaluation process contains face-to-face sessions that are combined with CyberLAB online activities. Questionnaires have been developed to gather the opinion of 160 students who undertook the evaluation. In general, evaluation results were very positive in regard to the different issues dealt with. Staff felt that the students were able to set up the instrument with better understanding during the actual hands-on session after learning thru the CyberLAB. Students felt that this mode of experiment learning is interesting and useful where they can practice the practical experiment at home without having to access the laboratory. A large majority of students responded positively to this mode of learning and enjoyed learning with this package.

Table 1
The responses obtained from 160 students during the evaluation

Evaluation element	Quality criteria	Question	Percentage of Satisfaction
Resources	Usability	The interface is user friendly.	95%
		The navigation is easy to follow.	92%
	Difficulty	It is easy for someone with minor computer skills to use the online course.	86%
	Clarity	The graphics/symbols clear to the user.	83%
		The layout (use of colours, fonts, icons) is appealing to you.	85%
Activities	Usefulness	The exercises are useful and meaningful.	88%
	Difficulty	The exercise is easy to complete.	85%
	Clarity	The exercise instructions are clear and precise.	88%
	Motivation	In general, the online course encourages independent learning.	93%
	Timing	You completed the 2 units of the online course in one hour or less.	87%
	Progress	In general, your level of technical skill improved after completing the online course.	87%

Conclusion

Unlike the theory-based online learning, CyberLAB provides an interactive web-based environment, consisting of virtual instruments and guided experiments on basic circuits to create a virtual laboratory for practical learning. “Good teaching practice is creative and provides energy, excitement, inspiration and enjoyment; ingredients that are essential for learning to happen.” [4]. The CyberLAB not only provides interactive animation but adopts the high level simulation technique in designing the virtual instrument. The design is refined to every detailed behavior of the instrument to achieve the real experiences and authentic learning environment.

With the remote online experiment feature, CyberLAB allows students to explore and conduct experiments over the Internet and to have an advanced understanding on the concepts of experiments and how to operate the equipment even before the actual hands-on session. With this advanced understanding on the operation of the equipment, CyberLAB has helped to reduce potential damage to equipment. Furthermore, the system facilitates revision. To avoid moving the experimental setup to the classroom or to overcome the difficulties of accessing laboratories facilities at any time, CyberLAB allows students to explore and conduct real-time experiments over the internet. CyberLAB has helped developed our students to be independent learners, allowing them to take charge of their own practical learning.

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Biographical Information

Shek Kwai Teng is a lecturer of School of Electronics and Info-communication Technology at Institute of Technical Education (ITE). As a graduate of Nanyang Technogical University in Electrical and Electronics Engineering with honours, her experiences in instrumentation control as well as simulation technology were applied to conceptualise, design and develop the interactive online learning material that enables the virtual replication of the learning of both the process and content of electronic laboratory for ITE students.

Tao Chong Meng graduated from Nanyang Technological University in 1994 with a B.Eng (Hons) degree in Electrical and Electronics Engineering. He worked in Singapore Power for 5 years where he vetted and inspected electrical installation drawings and switchboards of up to 22kV. Following that, he ventured into the field of industrial process plant instrumentation and control systems. Currently, he works in ITE College East, where he teaches electronics, computer systems networking and supporting the development work of CyberLAB system.

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