Delivery of Hands-on Technical Courses through Synchronous and Asynchronous eLearning

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***Abstract*— Technology has a profound impact in our daily activities, learning through the use of technology has no exception. Instructors often experience obstacles in designing their courses for distance learning. It is generally more challenging to deliver technical laboratory courses through web based learning. A research team encompasses faculty members from several universities and community colleges have developed instructional materials for delivering microcontroller embedded system designs. Technical training platform is designed and developed to support course modules which are delivered in both synchronous and asynchronous eLearning environment. The process of collaboration involves the use of several types of electronic media as a mean to facilitate conversations among members. Electronic learning tools such as video conferencing, web portal, web server, file sharing mechanisms etc. to support this distance learning project are discussed. In addition, the research findings of learner's attitudes toward the technical subject taught and learned using distance learning tools is addressed.**

***Index Terms*—online learning, instructional design, eLearning, Distance Learning.**

I. Introduction

The evolving use and the popularity of the Internet have a great impact in the educational field. The push to move education into using distance learning formats comes from many sources [1, 2]. Some are organizational internal demand, while others are external [3]. In this instance, there were the curiosities of a team of researchers who are willing to take challenge to the next level [4]. In addition to the push by their institutions to move courses and programs into a distance learning environment. These faculty sought external funding to assist them in their research to find solutions to delivering hands-on technical content courses using the advantages provided through electronic instructional delivery technologies.

The technologies developed and used by these researchers were supported by a three-year, proof of concept, National Science Foundation project. The initial year's work explored the needs for developing such a training platform to use in delivering instruction, so students could participate in laboratory activities guided by faculty, plus an additional design of an application project with microcontroller circuits. A technical training system was developed through an earlier research project (and initial instructional modules were written). Through this project, the total instructional support system was refined, additional learning modules were added, plus a set of laboratory modules were completed. During the project, the instructional system was tested through three summer workshops taught to 60 faculty members (2-year. 4-year, and high school) pre summer throughout the U.S. using distance learning technologies.

The mechanism used to deliver the workshop includes the use of synchronous methodologies such as video conference, and Internet related chat. In addition to, asynchronous media are also used to deliver the course materials such as the use of web portal for release general information regarding the course, Learning Management Systems (LMS) for distributing step by step instructional course materials, pre-recorded and archived videos, and discussion forums. The combination of synchronized and asynchronous distance learning methods complements each other thus enhanced the learning results.

Data collected through the summer workshops has shown that participants has positive attitudes toward eLearning experience, and that technical laboratory content and courses can be delivered successfully through distance learning.

II. Collaboration and Course Development

Prior to the workshop, the group of researchers realized that in order to deliver the subject area successfully in an online learning environment, common instructional materials and tools must made available to all learner despite their geographical locations. To overcome the issue, researchers have designed and developed a common hardware platform, a PIC (Peripheral Interface Controller) training system, to deliver this technical based subject. This trainer board allows all participants to have the same technical learning environment and associated laboratory tools of software and hardware that are available to them.

In this project, a PIC training system was designed and developed through the support of a previous NSF grant. The refined microcontroller laboratory board includes the following features:

1. All component parts are available from vendor purchases.
2. The system could be used with Microchip (PICKit2, PICKit3), NXP/Philips (LPCX), and Arduino systems for programming, simulation operation, and debugging.
3. Power options include +-5V, +-12V, +3.3V, digital and analog I/O, LCD, and LED displays, RS232 and USB communication capabilities, 2.4GHz wireless module, and high and low power isolation for digital/analog and motor drive controls.

4. OPAmp, EEPROM, DAC operations, and SPI Bus are available.
5. FET/IRF530*8 power for stepper and DC motor controls are also supported. [5]

The design of a common instructional platform played a significant role in eliminating technical issues in assisting troubleshooting while teaching practical hands-on courses. [6] Teaching and learning processes become much more convenient, efficient, and feasible in the distance learning environment. Both instructors and students had the same platform which significantly increases the efficiency in finding problems in hardware and software designs while implementing hands-on labs and projects. The custom designed platform also met the academic demands in teaching technical concepts that require hands-on practical experiences subjects such as microcontroller embedded system designs.

This tailored system was also designed by the researchers' with affordable budgets in mind. The trainer board is economical for student to purchase at approximately $130 USD per unit. Learners do not need to purchase any additional textbooks or laboratory manuals, since the instructional materials have been designed and developed by the research team and available to students and teachers on a remote server. These development efforts have made the teaching and learning of embedded system designs possible through distance learning.

Figure 1 shows the PIC training system that was designed and used in this project.

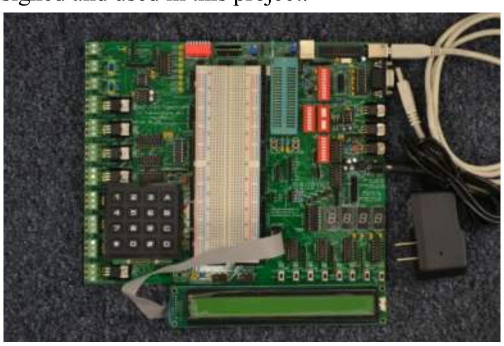

Figure 1 – PIC Training System

Besides the development of the trainer board, Researchers also develop curriculum modules, lab modules, and customized application software to deliver this online based instruction.

Course Instructional Modules

Course modules of instructional materials were created by the team members. A set of 10 instructional modules were first developed by the team members. To ensure the common terminologies and languages are used in the instructional materials, all materials were edited and presented in the same format and style. Although 10 modules have been developed initially, six additional modules were added at the later time. It was not intended that all modules to be taught/used in a single course; however, research team provided various instructional materials for participants to choose and adopt, so they can customize the materials any way to fit their curriculum requirements. During the workshop, seven modules were taught in a three day training session. Participants have expressed that they could teach approximately six to eight modules in a semester course plan. The research team's intent was to have sufficient modules available in different courses at either 2- or 4-year institutions. Table 1 listed all the microcontroller curriculum modules that are developed by the research team.

#	**Instructional Material Modules**
1	Microcontroller Technology
2	Numbers and Programming Languages
3	Register and Memory Programming
4	I/O and Routines
5	I/O and Watch Dog Applications
6	Interrupts
7	LCD Communications
8	Keypad Controls
9	Stepper Motors Controls
10	DC Motors Controls
11	ADC and DAC Controls
12	Remote Data Logging
13	Wave Forms Generation
14	PWM Module for Motors/Servos
15	Feedback Loop with IR Sensing and DC Motors
16	Multiple Processor Communication using a SPI-based Master-Slave Configuration

Table 1 Microcontroller Curriculum Modules

Lab Modules

The hands-on labs were designed and developed in associate with the instructional materials. There were 10 lab modules developed to help learners understand the subject area. Lab modules were introduced to learners after the instructor teaches the course content through their normal instructional practices.

The lab modules are designed to apply and reinforce the content of the instructional modules. These modules provide step-by-step instructions to assist students completing laboratory works. In addition, assessment worksheets were provided with the lab modules, so learners can answer questions on the worksheets. This serves as self-assessment for learners to evaluate their performance. It is also to be used for grading the laboratory work within the laboratory modules.

In order to ensure learning occurs with minimum issues to troubleshoot at the remote site. Instructional videos were developed by team members. Video files demonstrated and showed how the training board is to perform or control other mechanism at each lab module. These have been found to aid student understanding of laboratory outcomes.

Application Software

The application software MPLAB IDE and PICKit2 were used for circuit control and programming in this project. They were selected for couple reasons. First, they are provided by Microchip (www.microchip.com) for free, and second, they are widely and commonly used among microcontroller programming corporations. These software applications can be used for editing, creating simulations, compiling in Arduino, Assembly, BASIC, and C languages, and programming. The PICBASIC PRO compiler made by microEngineering Labs Inc. was also used in the trainer design. Overall, research and development were needed by the team in order to develop and perfect the training platform. Once it was developed it took the skills of curriculum writing to develop the instructor modules and student laboratory modules. Again it also took the knowledge of engineering to program the software to make the system interface correctly for instruction.

III. Instructional Methods

Asynchronized methods

Several mechanisms were used to deliver this online instructional project successfully. Web portal is one mean to deliver the instructional materials. Prior to the workshop, the trainer board were shipped to all the participants, and a resource web page (http://www.ucdistancetraining.org/preworkshop.php) were developed with information that users need. Resources in the website include software applications such as Initial Trainer Test, MPLAB IDE, XC 8, PIC Kit 2, Arduino, and PIC Training System. Learners need to setup and test these software applications with their trainer board prior to the workshop in order to participant in the workshop. Instructional materials for setting up and testing the training board were provided through the online webpage. In addition, instructions for using online video conference were provided in the page for learners to setup their audio and video equipment.

Server storage setup and access account issues was investigated; thus, learners can use the centralized service to download and upload course materials. The technology consultant researched the options available to accomplish this requirement. Some researchers choose to use their campus servers, while others choose to use Blackboard or similar Learning Management Systems (LMS) operated by their schools. This research team needed the capability to have all project faculty members capable of uploading content from their institutions, plus have plans for others who want to post shared materials related to microcontroller technologies onto the server. University servers have restricted access and firewalls to protect their servers from outside users. This project had to allow access for users from outside of the university domain. In addition, the research team wanted to post videos that supported microcontroller instructional materials, and laboratory demonstrations. This also required the posting of programming code, so users could download this for their microcontroller design functions. In order to accomplish all the needs and have a centralized file sharing location, we chose to implement the use of Moodle, an open source LMS, as a mean to deliver all the course materials to participants. Although Blackboard and Moodle merged in April 2012, Moodle remains an independent division and continues to serve the educational community in an open source format. Moodle is free, the project team purchased hosting server to host the Moodle service and the web portal. The centralized location allow users to have an access account to view, download and share course information. Shared Moodle modules at http://www.ucdistancetraining.org/moodle/ include but not limited to the follows, Pre-workshop materials, pre-recorded presentation videos, Lab videos, course instructional material modules, lab modules, lab programming codes, workshop lecture archives, lab assignments, and discussion forums.

Synchronized methods

The research team also had to choose how they plan to deliver courses via distance learning technologies. Faculty had experience with web-posting of course materials, but they sought to make the project's courses faculty/student interactive in delivery functions. This meant the courses would be offered real-time, with the instructor teaching and the students being about to communicate with the faculty member and other students in class. The researchers had worked with Adobe Connect using real-time distance lectures, conducting lab exercises, conferencing students, and creating audio/video archives.

The project investigator's university has a site license for Adobe Connect and three faculty had taught students using the system. Adobe Connect became the technology the faculty research team used to hold monthly meetings. Each participating faculty member was trained to use this conferencing system at a summer training workshop and then required to use it in monthly research team meetings.

Advantages of this system include its video and audio capabilities. Audio can be controlled and, when desired, students click on an application function requesting permission to speak. The faculty member is in control to allow student conversation to reduce possible audio chatter.

This system also allows the faculty member to focus a video camera onto the trainer, so students can see wiring configurations and watch demonstrations. The video-conferencing application also allows faculty to divide the class into sections, so different groups of students can conference (collaborate) with each other.

The research team found this to be an asset for their teaching, since during summer training of other faculty to teach microcontroller topics, it allowed for teaching using Arduino, Assembly, BASIC, and C programming languages. The research group chose to teach the main content of the summer training for faculty to all participants at the same time. When it was time to conduct laboratory activities, the class was grouped into four sections, one for each or the programming languages. Participants could then select the language they prefer and participate in this particular training. Some chose to learn another language that they planned to teach with in the future.

Another function that Adobe Connect has is its ability to allow for the recording of all training sessions/classes. Faculty can elect to record each class session and then can post the saved content at a generated URL. The faculty can then share the URL with students for their review. This allows students to use the video recording when they are conducting laboratory activities while away from the courses hours. It also allows the faculty member to pre-record a class session if they need to miss class.

Workshop Implementation

After the training equipment was re-designed and the instructional support package (content modules, laboratory modules, video segments, and codes) was completed and posted on Moodle, faculty from high schools, 2- and 4-year institutions across the U.S. were invited to register and participate in a 3-day professional development workshop that offers training materials via material sharing using asynchronous method and also synchronous instruction using the Adobe Connect distance learning technologies. The research team's intent was to provide opportunities to instructor and faculty to learn about microcontroller technologies using this training system/platform developed by the team. Participants can then share their experience with their colleagues or utilize the materials they received from the workshop in their own instruction.

The target participants for this project was the instructors at two-year colleges, four-year university faculty, and high school technology teachers. The invitation was sent to the potential participants based on geographical regions in the States – East, Mid-West, and West. Approximately 20 participants were selected from the registration pool based on the information they have submitted to attend a 3-day workshop from each region. Total of more than 60 participants was trained in the 3 workshops conducted during the summer (June, July, and August) for all regions.

Prior to the start of each workshop, the training equipment was sent to participants so each could test the training system to see how it worked and each participant was requested to log in to Moodle server to review the instructional materials that had been posted for instructional assistance. It was suggested that each participant log into Adobe Connect as a guest before the start of the workshop, so they could learn to use the conferencing technologies to be used for instruction. Various Adobe Connect test training sessions were scheduled.

During the workshops, there was a lead faculty who oversaw instruction, but instructional tasks were portioned out to members of the research team. Each training workshop was taught for 8-hours during each 3-day scheduled workshop, a total of 24-hours of instruction per workshop. Although offered electronically online, the courses were operated similarly to teaching a face-to-face campus course. The mornings began with an open questioning session, objectives for the session were reviewed, and content topics were delivered through a visual/ discussion process, again followed by questions and answers. Instructional videos of the training system were used to further clarify instruction. Close-up video of circuits were used by mounting cameras on tripods. After the content and its major concepts were taught, then the class was divided by language (Arduino, Assembly, BASIC, and C) for lab instruction. Breaks were also taken just as in other real time classes.

IV. Assessment

To determine the knowledge participating faculty had of microcontroller topics before the training began, a pre-test was administered. Three days following the workshop, a post-test was administered. The mean pre-test score for the 60 participants was 5.26. To verify the effectiveness of the workshop, a post-test was given at the end of the workshops, and the post-test mean score was 15.45.

Course module goals and objectives were used as the base to create the testing question. Total of 22 questions were created and used to measure the effectiveness of the intervention (workshop) Test results showed that on an objective test from the content chosen for this training, little was known about microcontroller concepts before training and sufficient learning did take place through the distance delivered instruction.

V. Conclusion

The overall goal of this project was to create an academic knowledge community for faculty interested in furthering the knowledge and teaching practices of microcontroller technologies (embedded systems). The research team embraces others interested in teaching microcontrollers to enhance collective thought on these topics. The team wants others to share their knowledge and expertise thought the online Moodle server. The team sees this as an extension to first enhance the knowledge of this teaching community and to use this added expertise to continue the group member's professional development.

The Moodle dedicated server would be used to share knowledge and support the continuous development of teaching and learning practices about developments within the specialty field of microcontroller embedded technology systems. The knowledge community can provide continuous communication via its listserv for the community and interested groups. In this way, members of the community could share new project ideas and new developments via the community forum. Faculty lessons, laboratory assignments and demonstrations, advanced projects, and chats could be posted. Questions of the unknown for a particular faculty member could be raised and then addressed by other members of the community. Additional professional development teaching lessons could be planned and delivered via the Adobe Connect technologies as new modules are developed by community members. This overall outcome is what the project team envisions as the continuation of explorations in teaching microcontroller embedded systems technologies.

The use of distance learning technologies can be adopted to the delivery of engineering technical laboratory courses. It is important to analyze the outcomes that one seeks from distance instruction and also to understand time is needed for initial preparation prior to instructional delivery. Identifying a common technical package for delivering instruction and development of supporting materials are important. Methods need to be planned and developed for the storage and access of information and teaching aids that support teaching.

The delivery technology then needs to be identified and training is needed on its use. During instruction, knowledge of learners and their acceptance of distance instructional technology are important. After instruction is initiated, constant updates and modifications will need to be made to achieve the instructional goals one sets for their technical courses.

Advantages of real time (active/synchronous) distance learning include the simulation of face-to-face laboratory environments. To have this occur, planning and developmental work are required.

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