Linking Theory with Experiential Learning in Virtual Learning Environment

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Abstract

This NSF-founded project presents work on new ways of delivering technical instructions to engineering students through distance using customized Virtual Learning Environment (VLES) tools. An important aspect of this paper is to present the efforts by a group of faculty from five different institutions, hailing from three different regions in the country. The goal of the project is to develop a curriculum for the dissemination of an Embedded System Course through active participation of students in the virtual environment.

The VLES has been designed to deliver technical instruction and course materials in embedded system design course through audio-video based distance learning. The supporting distance learning curriculum and laboratory modules, using modular instructional materials along with VLES training, will be presented. The curriculum has been tested through summer workshops which demonstrated that VLES can be used for real-time teaching and learning hands-on technical subjects. A curriculum focusing on embedded system programming and utilizing the developed training system, with lessons focused on Assembly Programming with peripherals interfacing modules, will also be presented. It is anticipated that the VLES, which is an open source framework, can contribute towards adoption in more institutions as the developed course modules are scalable. The active participation of participants for empirical lessons through audio-video technologies has been tested as a pilot program and its impact has been positive. In the future, our intent is to propose the VLES concepts as a new addition to current secondary education in the central valley to promote engineering and technology. Addition of the concept to the current curricula in secondary education will inspire students to pursue Science, Technology, Engineering, and Mathematics (STEM) disciplines at earlier age.

The project experience and data collected from the faculty who participated in the summer workshops will be presented including focus on the following topics:

- Design and development of the VLES and supporting instructional materials
- Link theory and experiential learning with active online participation
- Assessment of the learning experience
- Experience on collaboration on teaching at other academic institutions

Introduction

The goal of this NSF-funded project is to disseminate an effective Embedded System Course through Virtual Learning Environment tools (VLES). This project is based on a three-year timeline. During the first year of the project, a microcontroller training system was developed that paralleled the curriculum. This training board has various modular components, from basic items such as LEDs, DIP switches, and a breadboard, to more advanced components such as keypad, LCD display kit, and LED numeric display. Thereafter, a curriculum focusing on microcontroller programming and utilization of the training system was developed.

During the second year, the VLES, curriculum, and training board were used to train faculty members from high school, two-, and four-year universities from across the nation. They learned important embedded system principles along with how to operate the training system. The goal of the training was to enable faculty members to teach the curriculum at their schools. The training also included learning VLES principles to be able to teach the curriculum at their schools online. Since the VLES incorporates a free open source framework based on Moodle, it offers a simple tool for distance learning. Moodle is a learning platform designed to provide educators, administrators, and learners with a single robust, secure and integrated system to create personalized learning environments [1].

Design and Development of the VLES and Supporting Instructional materials

For effective delivery and feasibility of linking theory with experiential learning in virtual learning environment, a server based on Moodle for teaching and learning has been designed and implemented. A Moodle server platform was used to access all the course curricula information for learning and completing embedded system experiments. The Electrical and Computer Engineering Department at California State University, Fresno (CSU, Fresno) hosted the web server for the Moodle system which was used by all five different institutions. The Moodle server was customized, built, and tested at CSU, Fresno in the following five phases:

1. Ordering of the hardware/software components
2. Integration of the components to develop a Ubuntu based server
3. Implementation of the web server for using the Moodle system:
    a. Specifying and setting up the required components for running PHP
    b. Creating the required components for running MySQL
4. Implementation of the system:
    a. Uploading Moodle software to the web server
    b. Running the installer script (install.php) on the web server
    c. Implementing the entire necessary configuration
    d. Connecting Moodle system to MySQL database to store the data
    e. Setup administration and user access
5. Testing the system in four level:
    a. Administrative
    b. Teacher
    c. Student
    d. Guest

Installing Moodle on a web server is a challenging task, with constant user interaction to continue on the install prompt. The requirements for installing are that the computer in question has a Linux distribution, a web server such as Apache or IIS, PHP which is a web scripting language, and a database, using either MySQL or PostgreSQL. For the installation on the CSU Fresno server, we used Ubuntu 12.04, Apache, PHP, and MySQL. For the steps required, a search of the internet on installing Moodle will forward you to the Moodle installation page, where during installation, make sure to use the correct version of all the software in the documentation provided on the internet. Moodle supports multimedia dissemination with lesson videos, webcam and microphone enabled classes, as well as web-based assignment submission.

It also contains a discussion forum for students and faculty to collaborate and discuss assignments, problems, and projects.
The Moodle system provides the entire embedded system curriculum as well as necessary resources such as the PIC microcontroller datasheet and the training sheet for the PIC board. Each lesson plan was stored in individual modules that contain all of the instructional resources to learn and complete the lesson plan. The student has the option to complete the course in C, BASIC, or Assembly language. The first few lesson plans teach the fundamental steps for using the trainer board along with instructions about using the programming software MPLAB. This software is an integrated development environment which provides all the tools necessary to assemble codes for embedded microcontrollers. It has many features that support concepts through visualization and experimentation. The simulation tools allows students to follow their code line-by-line for effective debugging. Once the code is completed, the student can easily upload the code into the trainer system for implementation. The next portion of the curriculum consists of individual controls such as I/O interfacing using switches and LEDs. The curriculum then shifts to integrated microcontroller enabled systems design and programming. The LCD display kit and keypad controls are used to design systems that accept foreign input and direct output to modular devices. As the course progresses along the curriculum, the students design advanced systems for data logging, RF (radio frequency) sensing, motor controls, Analog-to-Digital conversion, and SPI (Serial Bus) protocols, etc.

Each lesson plan contains a Learning Module and a Lab Module. These technical manuals educate the students about the microcontroller architecture and how to incorporate it with PIC training system. The learning module describes all the conceptual knowledge required to implement the embedded microcontroller feature. It describes the applications of the feature and thoroughly shows how to configure the registers for proper execution. Flowcharts were used to guide students through the logical operation of each learning modules. The lab module contains all the information needed to make the physical connections. It includes schematics, diagrams, and photos. It also shows how to upload the program into the trainer board. Moodle and the instructional material provided the foundation for the course. The final tool to complete the distance learning experience was Adobe Connect. Adobe Connect is a web conferencing platform based at ODU for web meeting and eLearning purpose. The virtual learning environment of Adobe Connect allows interactive one-on-one communication with the instructor that provides an experience simulating on-campus learning. Each student was provided with a webcam and microphone to allow for a live video conversation. By having access to a live video, the instructor is able to see the completed project demonstration, help with troubleshooting, or provide any other special assistance. Adobe Connect also has a screen share feature so the instructor can view and control the student’s computer screen remotely. This access increases collaboration with debugging. The platform has the option to have a private conversation with the instructor or discuss embedded system concepts publicly with the class. Adobe Connect completes the virtual learning environment tools that resembles laboratory courses.

Supplementary Modules

The following three modules were developed at CSU Fresno and added to the curriculum:

1. Internal Pulse Width Module for Motor/Servo Implementation: A usage of the Pulse Width Module (PWM) was used to control the output of two DC Motors. This feature controls the speed of the motors with very minimal supervision. This enables the microcontroller to

perform other tasks while still managing the motors' speed. The setup is shown below in figure 1.

Figure 1. Two DC motor control.

2. Feedback Loop with IR Sensing and DC Motors: This experiment combines a distance measuring sensor and a motorized RC vehicle to create an embedded control system. The distance measuring sensor is the feedback signal, and the output is a DC motor which controls the position of the vehicle. The controller maintains the vehicle within 20cm – 30cm from a reflective surface. The setup is shown in figure 2.

Figure 2. Feedback loop embedded system.

3. Multi-Processor Communication using a SPI protocol: The goal of this experiment was to establish communication between processors using Serial Peripheral Interface (SPI). One processor was configured as a Master, and two were configured as Slaves. The Master was programmed to send a message to the Slaves consecutively. The Slaves were programmed to "listen" for the message and displayed it on an LCD. The hardware setup is shown in Fig. 3.

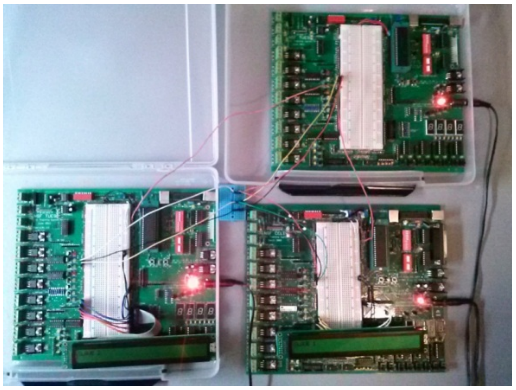

Figure 3. Multi-processor communication using SPI.

Curriculum Adoption at CSU, Fresno

The training board and curriculum has been adopted at CSU, Fresno ECE department to teach ECE 118 (Microprocessor Architecture and Programming) and its laboratory complement ECE 120L (Microcontroller Laboratory). Overall, the students are pleased with the curriculum along with using the PIC training system and accessing Moodle. In the future semester, student's learning outcomes in embedded microcontroller systems will be assessed.

Assessment of the Learning Experiences

The following is a statistical report for the summer 2013 workshop. There were total of ten modules; however, seven Modules (1-7) were used. However, the actual tests involved Modules 1-10. The Pre-Test and Post-Test scores are reported for Modules 1-7.

Participants = 56
Pre-Test: Mean = 5.26, Median = 4, SD = 4.97, and Range was 0-19
Post-Test: M = 15.45, Med. = 17, SD = 5.06, and Range was 6-22

Opinion Survey Results

Module Goals – I was able to (SA= 5 to SD = 1):	**Statistics**
1. Describe the fundamentals of microcontroller technology.	Mean=4.52 Median =5 SD = 0.57
2.1.a. Perform math and logic operations in different numbering systems.	Mean=4.23 Median =4 SD = 0.77
2.1.b. Explain basic logic gate operations.	Mean=4.49 Median =5 SD = 0.63
2.1.c. Program a PIC microcontroller in various numbering systems using mathematics and logic operations.	Mean = 4.11 Median = 4 SD = 0.82
2.2. Use STATUS flags to operate programmable intelligent computer (PIC) controlled devices.	Mean = 4.09 Median = 4 SD = 0.86
3.a. Explain the PIC16FXX embedded system circuit design.	Mean = 4.13 Median = 4 SD = 0.76
3.b. Use I/O pin configuration and control functions with an internal CONFIG register.	Mean = 4.27

	Median = 4 SD = 0.65
4.a. Explain the use of a flowchart for PIC programming.	Mean = 3.93 Median = 4 SD = 1.01
4.b. Calculate and write a time delay loop(s).	Mean = 4.07 Median = 4 SD = 0.83
4.c. Identify the ranges and uses of the DM and PM.	Mean = 3.59 Median = 4 SD = 1.02
5. Describe the structure, purpose, and potential applications of the WDT timer.	Mean = 4.27 Median = 4 SD = 0.67
6. Explain the structure and the application of interrupts, flags, global enablers, and individual enabler setups, interrupt handler hardware and software, IRQ configuration, polling vs. ISR (IRQ service routines), and prioritize IRQ services in the program control.	Mean = 4.11 Median = 4 SD = 0.73
7. Use parallel data communication between the microcontroller and other devices such as a LCD module.	Mean = 4.14 Median = 4 SD = 0.80
8. Use a matrix keypad interface.	Mean = 3.91 Median = 4 SD = 0.94
9. Use hardware/software for programming, interfacing, and testing with uni-polar and bi-polar stepper motors.	Mean = 3.38 Median = 4 SD = 1.07
10. Use hardware/software for programming, interfacing, and testing with DC motors.	Mean = 3.27 Median = 3 SD = 1.09

Training Opinions

Answers were coded 2 (Mostly Positive) and 1 (Mostly Negative)

11. What is your overall impression of the course modules for assisting you with understanding embedded technology knowledge and applications?	Mean = 2 Median = 2 SD = 0.00
12. What is your overall impression of the technical capabilities of the embedded learning hardware platform?	Mean = 1.95 Median = 2 SD = 0.23
13. What is your overall impression of learning using the embedded technologies system (training platform and modules)? Did it satisfy your learning needs?	Mean = 1.96 Median = 2 SD = 0.19
14. Were you able to learn to use this system through distance learning technologies?	Mean = 1.91 Median = 2 SD = 0.29
15. Do you plan to use distance learning technologies for instruction in the near future? Yes (2) and No (1)	Mean = 1.69 Median = 2 SD = 0.47

Points of interest:

- Very good feedback from the participants.
- Major growth from pre-test through post-test scores.
- There were 22 possible correct answers from the test questions on Modules 1-7.

- Post-test mean was 17
- Good for the mixed experiences of our 56 participants.

The follow-up survey shows where we stopped teaching content at the end of Module 7 because of workshop time shortage; this is indicated by lower mean scores on the questions. The overall assessments of regional joint efforts are shown in Items 11-15, where _"2"_ indicates the high score and _"1"_ indicates the low score. The median response is _"2"_ for all of these items. A most interesting revelation showed that 69% of participants reported considering using distance learning in future technical instruction. The average score on correct responses to the knowledge pre-test was 5.19. The range was 0-19. There were many participants who expressed lack of familiarity with embedded technologies before the workshop. The post-test results was 6-22, with the average score of 15.45; a significant knowledge increase.

Follow-Up Survey Open-Ended Questions

This curriculum was used in teaching faculty from various universities in summer 2013. The faculty members were provided with the tools necessary for the cyber-enabled course, i.e. the PIC microcontroller from Microchip and the PIC training board developed. 21participants expressed interest in teaching technical concepts via distance learning; this attests to their overall satisfaction with our distance delivery capabilities. 30 participants indicated that they could learn to use our distance learning system, while 32 reported satisfaction with the trainer and the supporting curriculum. The developed training system and curriculum has been adopted by the Electrical and Computer Engineering department at CSU, Fresno to teach ECE 118 (Microprocessor Architecture and Programming) and its lab component ECE 120L (Microcontroller Laboratory). Overall, the students responded positively to the PIC training system, accessing Moodle, the curriculum, and Adobe Connect. There are future plans to assess students' learning outcomes with regards to use of embedded microcontroller systems.

Conclusion

This project promoted the use of efficient curricula for hands-on engineering courses and via the development of an effective teaching methodology for microcontroller technology. The result of the summer workshop demonstrated that VLES can be used for teaching and learning hands-on technical courses via real-time VLES. The affordability of the training system and simple access to the curriculum will promote interest in the STEM fields at an earlier age. It is believed that this tool will stimulate a stronger workforce in the area of embedded systems.

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