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A Model for Producing Internet Technology Courses

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ABSTRACT

While the traditional face-to-face university setting has many advantages for teaching complex technical material, the sheer volume and increasing specialization of advancing technology force a change in academic delivery methods to produce a well-rounded engineer. It is increasingly difficult for universities to afford wide experience diversity in their teaching staffs, or the equipment required for laboratory work across the broad field of each engineering discipline.

The internet provides vast opportunities for accessing course material to supplement a university's traditional offering . However traditional delivery methods, relying heavily on text, have limitations for high-tech courses because students tend to require direct contact with a professor to answer questions and interpret complicated text. Course preparation for internet delivery must extend beyond the centuries-old pedagogy of face-to-face teaching practices.

This paper outlines an advanced embedded controller and device driver design course currently being tested as a remote learning class at Miami University, Middletown, Ohio. The course developer is a resident faculty member at Weber State University in Ogden, Utah.

1. INTRODUCTION

In the 1990's Weber State University began an on-line program for full university credit, and the Department of Computer and Electronics Technology participated. The author prepared 3 courses for the department, relying on traditional text books, his collection of classroom lecture notes, labs and other materials used in his traditional courses. Although the university continues its on-line and distance learning programs in other disciplines, the CEET department discontinued its participation after 6 trying years.

The motivation for halting CEET on-line courses was not lack of interest on the part of students, but rather the high rate of frustration among enrolled students once they got into the course material without an opportunity to interface with a live instructor. Technical material was difficult to grasp, and even more difficult to apply without frequent access to the professor. The author ended up holding weekly help sessions for the on-line students, most of whom were attending other classes at the university and taking the course on-line to solve class schedule conflicts. Students who were unable to attend the help sessions dominated professor office hours for additional help. Very few remote students completed the courses successfully. With disadvantages far outweighing the benefits of the program, it was abandoned.

While on a sabbatical leave from Weber State University, the author was a visiting professor at Miami University in Middletown, Ohio, where he taught a course he developed for embedded controller and device driver design. The Miami University ENT Department wished to continue the course, prompting a new look at the possibilities of internet delivery. The balance of this paper investigates the methods used to create an advanced, highly technical and application based distance learning course without compromising student understanding and hands-on laboratory experience.

2. PRELIMINARY CONSIDERATIONS

Recently, institutions pursuing on-line degree programs, and other private support organizations have conducted research into producing quality courses that address the specific challenges associated with distance learning (e.g. Hixon, 2008a; Oblinger & Hawkins, 2006; ION, 2007). Researchers conclude that the best approach to quality course production is through collaborative teams with representatives to include at the least a project manager, an instructional designer, an IT expert, and the faculty member as a "subject matter expert" (Hixon, 2008b). While such teams will undoubtedly produce a superior product, the average professor in a high tech teaching assignment has neither the time nor the administrative support for this type of undertaking. Most find themselves alone with their subject expertise and some skill with the technology required to meet a demand for an on-line course. For this reason, the following discussion outlines some considerations based on the author's own experiences with on-line course development.

2.1 TEXT SELECTION

As the subject matter expert, who in the process of on-line course development must also wear the hat of the instructional designer (pedagogy expert), the professor must take into account considerations that go beyond the criteria normally used in selecting a text. Of course a text must be comprehensive, but it must also be highly comprehensible. If text reading assignments are a part of the course objectives, there will be no one to interpret the often poorly worded, rambling and disorganized explanations found in many text books.

According to Illinois Online Network "Key Elements of an Online Program (2007), some essential elements of on-line curriculum include organization into modules, with clear and concise concepts and deadlines for assigned work related to each concept. The curriculum "should focus on application of knowledge to the real world and foster critical thinking skills with opportunities for an interchange of ideas among students and with the facilitator" (p.2). As the author was unable to find a suitable text book that incorporated this important consideration, he chose to write his own in a CD format for easy delivery.

2.2 LABORATORY REQUIREMENTS

In the opinion of the author, hands-on laboratory experiences are an essential bridge between engineering theory and application to the real world. A successful online course must somehow incorporate these experiences with equipment and materials the students can access. The labs must also have clear instructions and concisely worded expected outcomes so that students complete the experience with no outside help. This important component is fairly unique to technology curriculum, and it requires a great deal of creativity to incorporate. A later section illustrates the lab component for the course model.

2.3 PRODUCTION AND DELIVERY REQUIREMENTS

The nature of online courses requires a variety of media and the equipment to support it. The professor must be able to capture the audio lecture in some manner and incorporate written text, illustrations, demonstrations, and all other creative support to make the lecture informative, interesting, and motivational. There are a variety of options available, but most producers will be limited by whatever resources their university has on hand, often simply a computer with a webcam and a microphone.

Additionally, the lecture must be deliverable to the student. Hybrid online courses have their students in an actual classroom to receive the digitized lecture and lab instruction. A facilitator prepares the computer, LCD projector and screen at the receiving end. At the send end, the professor may be live, or as in the case of the model presented in this paper, has pre-recorded his lecture on a CD or has sent it to be downloaded off the internet. Actual interaction between students and professor requires an interactive program such as WebCT®, Illuminate® or Mimeo®.

The conventional online course to be delivered to a student at home must be downloadable through a server or delivered on disk through the mail. Interaction with the professor requires at least a high speed internet connection for chat room or e-mail contact, and a webcam and microphone for live chat.

3. THE MODEL ON TRIAL AT MIAMI UNIVERSITY

3.1 COURSE CONTENT

As subject matter experts, professors tend to enlarge their subject matter as they develop curriculum and prepare lectures. Producing content for online courses requires a skill to perform just the opposite. Content must be reduced to no more than its essential elements, with the details and nuances of the subject left for students to discover through their own in the process of completing assignments, labs, discussion groups, or other activities designed into the course (IONb, 2007).

"Embedded Controller and Device Driver Design" was developed as a traditional course; however the text was created for a CD, a format which requires much the same mind set as online content. Web designers have discovered that reading off a computer screen is not the same as reading a book, and they incorporate strategies to reduce text and enlarge visual images to get their messages to site visitors. Any text designed for digital delivery must do the same for students.

Having already reduced the text component into modules, concepts and supporting elements made it easier to prepare the rest of the course for digital delivery. Many illustrations were already in the text. Lecture preparation was based on anticipating the questions students would have after exposure to the modules in their CD text, as well as emphasizing background information required to complete the assignments and labs. While certainly not perfect in this respect, the course trial at Miami University has produced positive feedback from the students in terms of their initial grasp of the material and ability to feel success with their assignments. The following illustrates a page of the CD text containing the concept and graphic support.

CONCEPT 1: The Universal Serial Bus (USB)

The universal serial bus came about as a natural evolution of electronic data transmission circuitry. As the ability to handle data faster and faster created faster devices, a universal asynchronous receiver transmitter chip set was developed.

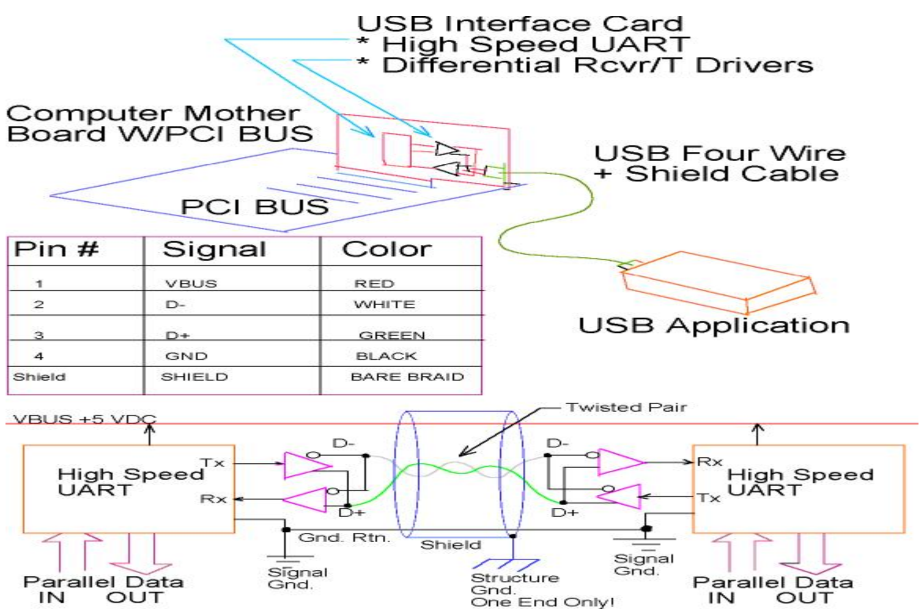
The first USB system could send and receive serial data at a 40 MBPS rate for what is called USB 1. USB 2 is rated to send data up to 400 MBPS. This newer internal bus speed is about 6 times as fast as the original Pentium computers of just 5 years ago. With the new faster computer internal PCI bus speeds, and the new ultra fast UART chip sets, the stage was set for higher speed serial communications. The motive was faster networking and the ability to network directly from computer to computer.

Another standard that uses the same differential data transmission scheme as USB is Fire Wire®. Fire Wire® is basically the same thing as USB but from a different manufacturer. Both are gaining wide acceptance, but with the advent of USB 2 (10 times faster than USB 1), USB 2 seems to be becoming the new high speed serial data standard of choice. This is mainly due to the hot pluggable connector feature, which allows you to connect and disconnect USB without damaging hardware.

In the future you will see most computer peripherals accessible through a USB 2 port. The USB pin connection will likely be the same and accept slow devices like the mouse and key board, up to ultra fast MODEMS, video systems, and network interfaces. Even display monitors will probably connect to a USB port. Having only one type of interface will make the computer more compact and more versatile.

A lot of things have been done efficiently to create the USB port. It carries its own power (+ 5VDC and a power ground). It has a differential serial data output port, and a differential serial data input port.

Both use the RS-422 differential data transmission standard that cancels common mode noise by a factor of about 100,000:1. Adding twisted pairs and shielded conductors, the cable gives the system an additional 27dB of noise shielding if the shield is grounded only on one end. The net result is 1,066,000:1 of noise reduction. This noise reduction allows very subtle variations in phase and voltage level changes to be detected. RS-422 systems can routinely send data for more than a mile over the same wires without any intermediate processing. Figure 8 below shows a typical USB system using RS-422 differential receiver transmitter pairs.



Pin #	Signal	Color
1	VBUS	RED
2	D-	WHITE
3	D+	GREEN
4	GND	BLACK
Shield	SHIELD	BARE BRAID

FIGURE 8: USB PORT DESCRIPTION USING A HIGH SPEED UART AND RS-422 DIFFERENTIAL RECEIVER / TRANSMITTER PAIRS

Figure 1: Sample Page of Text Concept and Illustration

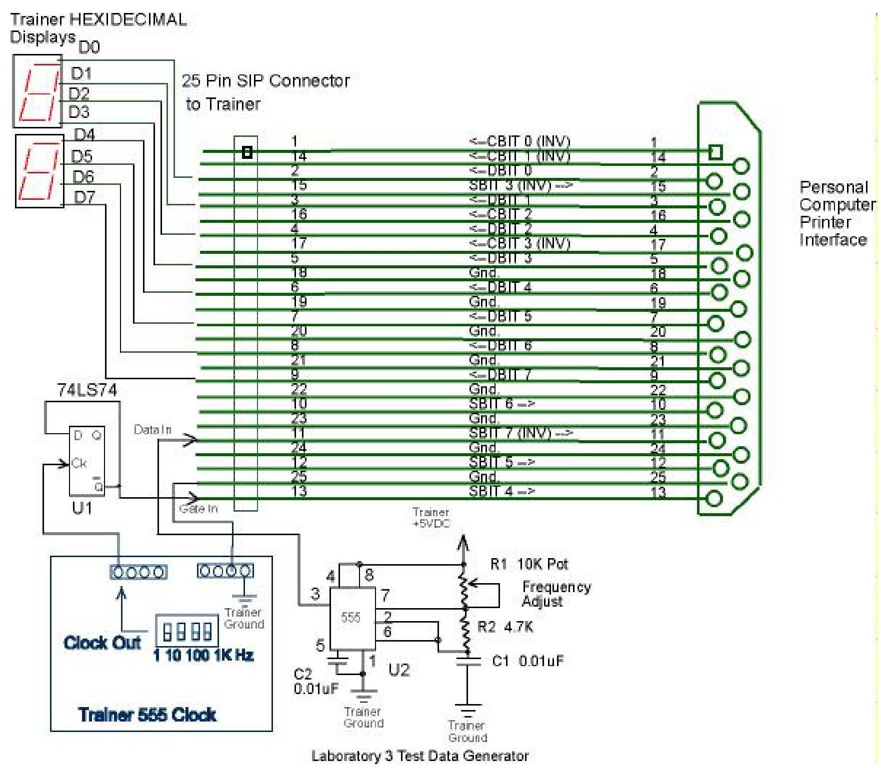
3.2 LABORATORY EXPERIMENTS

Because the course is actually a hybrid online offering, which means there is a classroom meeting at the university once a week, during which students perform the week's laboratory experiment with a Miami University professor acting as facilitator. Students have the CD text, containing the module reading assignment and homework, which they are expected to have completed before doing the lab work. During the weekly meeting, the author has an open internet link using Illuminate® to answer questions and interface with the entire class.

Lab experiments are designed to give active and real world applications of concepts covered in the weekly modules. Instructions need to be very concise, and the experiment's expected outcomes should be distinct and clearly related to the module concepts. It is especially important that this component of an online course is carefully constructed because the experiment process allows students to synthesize information and draw their own conclusions. Basically, they internalize information through performing hands-on practice with the course content.

PC PRINTER I/O PORT BINARY EVENT COUNTER

LABORATORY EXPERIMENT #4



2. Write a simple program that will look for events on the Status Bit 7 input and increment a counter each time a transition from low to high is detected. Your program should output the 8 bit count to the two HEX displays on the trainer and also show the count on the computer screen. There should be a screen legend that says "Event Count = ". Display the count on the computer also as two hexadecimal characters. Your program should clear the count or reset the count to zero if a "DEL" is detected, and should exit the program and return to DOS if an ESC is detected. The short block of code below shows you how to convert from the 8 bit binary count to two ASCII characters that represent the two 4 bit hexadecimal characters.

Figure 2: Sample Lab Figure with Instructions

This course culminates with a student project, applying the design concepts and software applications presented throughout the semester. The course content and lab assignments guide the student towards this project from the first week, so there is a scaffold of support throughout the semester, and past students have experienced great success with their projects with a minimum of professor interaction.

3.3 PROBLEM SOLVING

Assigning problem sets as homework has long been an effective strategy for developing critical thinking and problem solving skills in technical courses. It is no less important in the online environment. However, in designing problem sets, it is important to remember that when students encounter problems for which they have not received sufficient information to solve, they do not have the recourses to turn to for help as in the traditional environment (i.e. peers, graduate mentors, professors). Every problem assigned must be carefully evaluated, making sure that required background information is either provided, or given as a reference. The professor can never assume students know relevant information, and there is no way to assess their background as there is in the face-to-face classroom. Creating practical application problems for this course was often a tiresome and time-consuming process, as every problem had to be broken down into its components, which then had to be traced to the content material to insure the answer could be found there. As tedious as this was, it served as a double check for completeness in the text content.

(Module 3) **PROBLEM 6**: The keyboard Scan Code for ESC is 01H. Find the BIOS and write a short routine to test for a key closure, if there is one. Test to see if the Scan Code is 01H. If it is, call a subroutine called DOS_EXIT.

Problem analysis: Can students define "keyboard Scan Code"? Discussed in Module 2.
Do students understand BIOS? Discussed in Module 3, Concept 1.
Can students define "key closure? Discussed in Module 3, Concept 1.
Do students understand subroutines? Discussed in Module 1.

Figure 3: Sample Problem and Problem Analysis Process

3.4 ASSESSMENTS

Assessments ultimately determine if course objectives have been met. For the device driver course, modules are organized into units of two or three modules, with a written unit test for each. There is also a written midterm and final exam. The tests are generated by the course author, but they may be administered and graded by the facilitator. Homework serves as practice and is allotted points for on-time submittal to the facilitator in the same manner as lab write-ups. Because practical application is the most important outcome of this particular course, the final project constitutes 40% of the course grade. There is a precise grading sheet for evaluating the project, and the course facilitator may also grade it. Since students are enrolled in the course through Miami University, the administering department maintains complete control over the grading process.

3.5 TECHNICAL CONSIDERATIONS

The technical considerations for preparing "Embedded Controller and Device Driver Design" as a distance learning course were driven by the personal resources available to the professor, and those available to the receiving institution. It should be noted here that this course, while delivered in a traditional environment at Weber State University by the author, was adapted for online delivery as a private endeavor without using WSU facilities or equipment. While this bypasses the sticky issues of intellectual property ownership, it also limits the resources that were used in production.

The CD text is a compilation of author-copyrighted Word® files, with supplemental material consisting of free software, or files included with permission. All illustrations included in the text are author-generated. The CD is distributed to the students through their campus book store, and is part of a complete package of text and laboratory materials. The package is described in a later section.

The medium chosen for online lectures is Microsoft PowerPoint®. PowerPoint® allows for text, integrated with graphics, audio overlay and video, although the quality of video compression is poor. Still, with cost as a major consideration, and the use of video more of a gimmick than a necessity for this course, video quality was not a major issue. With this medium, the lectures can exist as a hard copy on CD or DVD, and are also downloadable through the internet. In the case of this hybrid course, the facilitator at Miami University disseminates the material weekly. Students do the reading and access the lectures on their own, then meet every Thursday for the lab. Because they purchase their lab materials and text together, they maintain control of their materials.

Besides a computer equipped with PowerPoint®, the course author uses a webcam , a standard USB microphone, and a digital video camera with still shot capability. The video component of this particular course is somewhat a novelty – a method the author uses to develop a relationship with his students by inserting brief, hopefully amusing personal vignettes to spice up the lectures. Using audio overlay to provide relevant information pertaining to the text or graphics on each slide keeps the lecture more concise, and feedback from students indicates they appreciate this format.

Miami University purchased Illuminate® as an interactive program for their distance learning program. It allows for a live feed so that the professor and students can see one another on the computer screen as they conduct a weekly question and answer session. One of the drawbacks of the program is a lag time, which, while annoying, does not prevent the questions and answers from reaching their intended audiences.

3.6 STUDENT COURSE PACKAGE

The course package was not specifically designed for distance learning, but it serves very well in the online environment. The course uses the TI 430 Microprocessor Module with support software from Texas Instrument, all of which is in the package. All other course specific modules, connecting hardware and electronic components are included in the package, along with the CD text. Students currently pay about $166.00 USD in the bookstore for everything they need to complete the course. This is not out of range for a typical advanced engineering course's text and lab fees, and the students retain all their materials, which may be used in other applications.

For a more in-depth look at the course package, please refer to LACCEI's 2008 paper publication CD under *A Course Design for Teaching Embedded Controllers and Device Drivers* by Robert A. Summers.

4.0 CONCLUSIONS

The object of engineering institutions is to create engineers with the ability to tackle and solve real world engineering problems. Each independent university's ability to give its engineering students the best possible education may well lie in its ability to access and share quality courses with other universities employing different expertise. The very nature of well-constructed distance learning courses, i.e. limited text, voice overlay lectures, increased graphics and well-constructed activities, lend them to translation from one language into many. This makes the concept of creating and sharing courseware ideal as an international activity.

Good courseware is a team effort, but it requires a great commitment of time and talent, and the development of quality distance learning courses must be rewarded. This indicates an additional component, that of private business, to bring together an international pool of engineering experts capable of providing a broad range of available courses. Private enterprise will also provide the expertise to administer project management, copyright protection, marketing and compensation for the work performed.

While this paper is an overview of one course enjoying modest success as a distance learning vehicle, it suggests a much wider potential for increasing the quality of engineering education worldwide. May the author suggest a vision consisting of teams of LACCEI educators with the talents and expertise requisite for internet delivery of engineering curriculum throughout the world.

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