DEVELOPING METHODOLOGY & TOOLS FOR STAND-ALONE, SELF CONTAINED TECHNICAL ON-LINE COURSES

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Weber State University

ABSTRACT

Many studies have been conducted that show that the majority of students perform better and have a more successful experience in a live classroom setting than they do when involved in any kind of remote learning situation. This is statistically true, regardless of the criteria used to measure student success. Several reasons for the different levels of success are: The professor in the live classroom ideally acts as a coach and mentor to the students, focusing on each individual and encouraging progress through personal contact, while the remote student must be self motivated; and the live lecture utilizes personal contact and verbal explanations to teach difficult concepts. Our ability to learn inductively is based on a foundation of skills taught to us by other human beings. A third element that especially applies to technical students is the availability of parts and equipment to perform laboratory experiments and applied learning activities. Most schools have well equipped laboratories, staffed with laboratory assistants to guide the students through assigned projects. Remote students traditionally have had to get parts and equipment on their own, rely on available local facilities, use only computer synthesis of the laboratory experiments, or not do the hardware part of the learning exercises at all.

Working on a grant from the Utah Educational Council and funding from Orchid Educational Enterprises, Inc. (OrchEd ®); Dr. Summers researched methods of remote presentation of technical material that bridge the gap between the university classroom and student studying the material over the internet or through some other remote study program. Using his own “on-line” students as a laboratory, Dr. Summers was able to improve their performance and success by recording streaming lectures of key learning concepts, and developing circuit design trainers and experiments that his students could use anywhere to build and test each learned concept. The teaching packages produced and tested by Dr. Summers included state of the art multimedia CD ROM text books, recordings of streaming white board lectures on each learning concept, laboratory circuit design trainers, laboratory parts kits, parts descriptions and documentation, and CD ROM laboratory manuals. The CD ROM text books Dr. Summers produced contain pictures, illustrations, written text, audio text, video clips, and white board streaming lectures complete with an audio track and full color interactive controls. By using Authorware ® by Macromedia ®, Dr. Summers was able to compile the information onto a CD ROM in a format that is easy to navigate.

This paper outlines a study of on-line student performance versus their on-campus counter parts. It also takes you through the model of a remote learning package developed by Dr. Summers, and outlines how to use the various equipment and software packages he assembled to develop his project. It discusses resources that are now available and shows how to make the remote learning situation emulate the live classroom to the extent possible. Dr. Summers also discusses how to use commercially available laboratory trainers and laboratory parts kits to provide remote students with a viable “hands-on” experience.
PROJECT DESCRIPTION

At the outset of the project, some very definite goals were outlined with the ultimate objective of making the on-line course more like the live classroom experience. In the classroom, students are in touch with the professor who is a personal motivator. The professor explains the material at the board, brings personal experience into the classroom, and works problem examples. Students can ask questions and go over the material as much as is necessary for understanding. The professor will often bring outside examples into the classroom in the form of short videos, pictures and illustrations. When the text is weak in a particular area, the professor will use personal experience or other resources to help explain the material in a different way. The main deficiency of on-line courses is that they almost universally lack this mentoring environment with the feedback that is available in the live classroom. We identified four main tasks that needed to be accomplished to better approximate the live classroom experience for our on-line students:

1. On-line students need some type of interactive access to either recordings of the lectures or some type of lecture like presentation of the most important concepts. This media should allow students to see pictures, watch and listen to lectures, view video clips, and have the same experience as the on campus students.

2. On-line students need a better way to interactively conference with their instructor.

3. On-line students need an inexpensive way to perform laboratory experiments on their own, outside of the university campus. They need self-contained laboratory equipment with parts, and experiment guides outlined and presented on electronic media.

4. There is a pressing need to improve the methods of personal progress assessment and student motivation. On-line students should feel part of the campus community and be able to know where they stand academically. They should also be able to assess their understanding of the material upon completion of any given module.

In the course of trying to meet this challenge, we experienced many false starts, looked at and tried many software and hardware solutions and systems, and had many disappointments. In the end, we succeeded in finding methods to accomplish everything we desired to do in a cost effective way that will benefit the students, professors, and universities alike.

The main solution is to use a method of electronic publishing that compresses white board presentations into “streaming lectures” that can be recorded on a CD ROM and subsequently viewed interactively by students on their own computers. Along with the streaming lectures, the professor will include a summary of the key facts, principles, applied problem solutions, and laboratory experiments. All of this and any supplemental material is then written and electronically published as a stand-alone textbook, or an enhancement to an existing paper textbook. The published material also includes audio text. This allows students to read along and listen to the text at the same time they observe pictures and illustrations. The same software that allows capturing of lectures for presentation in the CD text also can be used for live conferencing. Using this software, a "live" help session can be set up to satisfy the second task listed above. For students to be able to do the laboratory experiments on their own, the experiments must be well thought out with a good experimental procedure included on the CD text. To cover the hardware needs of the laboratory, students purchased a laboratory trainer and laboratory parts kit as a supplement to the text. The trainer provides the students with all the equipment, parts and
Our first project is a soon to be published CD ROM textbook for our Introduction to Digital Electronics test course. The first two weeks of the course were developed and published for the spring 2002 on-line students. Their success rate based on tests scores and completed homework assignments went up significantly. Students praised the streaming lectures and audio text, and were disappointed when they had to return to the normal course material. The material was published directly on the Weber State University on-line server. Because of the viewing demands and high bandwidth required, several times our students choked the WSU system, prompting the alternative approach of publishing the material directly on a CD ROM. The CD ROM will be distributed at the beginning of the course, allowing the students to access the material on their own computer any time and as often as they desire.

The Weber State University Computer and Electronics Engineering Technology department in partnership with Orchid Educational Enterprises, Inc. has established an electronic media development laboratory on campus at WSU. The purpose of the laboratory is to provide equipment and software and expertise for on-line professors to develop streaming lectures and CD textbooks for their courses. The CD text for Introduction to Digital Electronics is being developed in the laboratory and is scheduled to be published by Orchid Educational Enterprises, Inc. early this year.

Weber State University On-line has since added the student portfolio system where students can view what the professor has recorded about their personal progress in the course. In addition, the CD textbook will have a test section with a pool of test questions that cover each module and related concept. The computer will generate a random test for practice, or a test that can be uploaded to the professor for a grade. Since the questions are randomly generated, students will have a difficult time cheating on the test. The professor can use these same test questions to generate examinations, or modify questions from the pool. Through the CD media, complex drawings and scientific symbols can be used in the test. Pictures, illustrations, and even animations can be added if desired.

THE DEVELOPMENT PROCESS

The initial phase of the project identified the hardware and software needed to accomplish the goal of making the on-line experience as informative and encompassing as the live classroom. The selected programs and equipment had to do the following:

1. Capture both the writing and sound of live white board lectures and compress the captured lectures into smaller blocks of data that preserve each session. The final data format had to be easily viewable at the student end, using common computer equipment and inexpensive software.
2. Be able to support live video conferencing for periodic on-line help sessions. The output had to be easily viewable by the students and if possible, students had to be able to either talk back or respond with written questions in a live, interactive "chat room" environment.
3. Capture short view clips and compress them into MPG format for subsequent viewing, and be able to append these video clips to the appropriate lecture session.
4. Capture written text, photographs, and illustrations as part of the lecture package.
5. Synthesize audio speech to verbalize the written text to allow students to listen to the text as well as read along. (Although we were successful in incorporating this feature using a software package called "Dragon Speak®" that would actually read and verbalize a block of text, it was abandoned in favor of recording a live reader. Even though the recorded audio text required much more data storage space, the computer-synthesized audio was too mechanical and impersonal. It sounded like the automated messages at the airport.)

6. Record sound bites (and audio text) as compressed WAV files that can be incorporated into the lecture package.

7. Organize the data into an interactive, navigable package with hypertext and data search capability built in. The final data must be both publishable on the on-line web or on a self contained CD. (The CD option was chosen as the preferred method of distribution because it could hold the vast amount of data generated, was relatively inexpensive to produce, and made all of the material available to the student without tying up valuable network bandwidth.)

During the investigation phase of the project, we evaluated dozens of software packages. Some were easy to use but ineffective, others were powerful but user-unfriendly and required a steep learning curve, or parallel complex and expensive hardware. Where possible, we used utilities that come as part of the normal operating system of a computer such as the audio recording utility that captures and compresses WAV files, or the "Quick Time" player that allows viewing of MPG video clips.

Two packages contended for the job of organizing and managing the material, Front Page® by Microsoft® and Authorware® by Macromedia®. Although the Authorware® package was more expensive and required a much steeper learning curve to use, it was selected over the Front Page® package because of its versatility and superior finished product. NOTE: This grant did not pay for any of the software studied or used by this project. Most of the software used is licensed to Orchid Educational Enterprises, Inc. The grant provided wages for student help and purchased some needed hardware.

The selection of Authorware® as the integration package allowed the use of "Rich Text Format" (RTF) that can be generated by Microsoft Word®. It also provided for the direct integration of any picture or illustration that is in JPG, BMP, or GIF image format. Since most systems now compress images into JPG, this was also a powerful feature. Because Authorware® has "Hyper Text" capability, it was easy to design an interactive navigation system into the CD textbook. One additional feature that was programmed into the Authorware® engine by some manipulation of existing features was the ability to search on any text word or phrase and then to jump to any matching location. This electronic indexing feature now made the Authorware® solution superior to anything else available.

The "streaming lectures" are captured using a combined software and hardware package called "Mimio"®. It captures in full color anything that a professor writes on a white board, and simultaneously records the audio. It was selected over a competing system called "E-Beam"® that worked in a similar fashion but was more difficult to use as a lecture capture tool, and did not provide the parallel audio track option. The only remaining problem area is with the program used to play back the "streaming lectures".
A program called "Real Player"® was selected because it was available as freeware and worked seamlessly with the SMI lecture files. If the user is willing to endure brief advertisements, the player is a powerful engine for viewing and listening to the "streaming lectures" and the live video conferencing.

The only problem remaining was a result of the Windows® operating system changing from 16 to 32 bits in the form of Windows XP, Millenium, 2000, NT etc. The free version of "Real Player"® does not run smoothly at present, and the upgrade will cost the users approximately $20.00. The new version of Quick Time that is part of the new Windows operating systems is supposed to work for SMI files, but our attempts to make it play have thus far failed. For Windows 98 on down, the present software works flawlessly.

To further facilitate the development of electronic media for on-line courses, we have generated a check list of things professors need to do to produce a finished product. The following is a suggested outline of materials the professor needs to compile on his or her own to master an electronic textbook:

1. **TITLE PAGE** – Show credits, descriptive title, author's name, and all vital material that identifies the text.
2. **TEXT PREFACE** - A written paragraph or video clip of the author introducing the text and course material.
3. **ANTICIPATED AUDIENCE** – This determines the level of the text and to whom the text is written.
4. **ABOUT THE AUTHOR(S)** – This page should include pictures of the author(s) and a brief outline of the author(s) experience, credentials, and interests. A short video clip of the author(s) introducing themselves is appropriate.
5. **DEDICATIONS AND ACKNOWLEDGEMENTS** – Everyone who inspired and contributed to the author's effort.
6. **SUGGESTED STUDY GUIDES AND SYLLIBI** – Give the scholar a guided path of study with suggested reading and exercises. Include several paths for different levels of understanding.
7. **TABLE OF CONTENTS** – Outline the title and content of each learning module and supporting concept.
8. **TEXT OUTLINE AND TEMPLATE** – Outline each text module and the concepts to be learned under each.
9. **TEXT AND LECTURE MODULES** – This is the meat of the text. It should include "streaming lectures", pictures, video clips, drawings and illustrations, and written text that explains each concept in as much depth and detail as is necessary to insure a complete understanding of each concept associated with the learning module.
10. **SUPPORTING LABORATORIES AND LEARNING ACTIVITIES** – Provide a "hands on" experience for each new concept learned. Outline the experiment in some detail, showing equipment and needed parts. Include video clips, pictures and illustrations.
11. **HOMEWORK PROBLEMS AND APPLICATION EXAMPLES** - Use any means described above to show students how to apply and use the newly learned concepts.
12. **TESTS AND ASSESSMENTS** – Give both the student and the professor a way to assess a student's progress. Make tests similar to homework and cover those main learning concepts and their applications. Include a bank of test questions that can be used to make up tests for self-assessment or graded examinations.
13. **SUPPORT MATERIAL** – In electronics, this could be device specification sheets and applications. The author might also want to include data tables, math theorems and derivations, tutorials, and information to support laboratory experiments and applications.

14. **FORMS AND STANDARDS** – Include examples of how final work and reports should look and what they should contain. Include templates and suggestions of how to better communicate technical ideas, research and data.

15. **WORK SOLUTIONS** – Include answers to key homework problems and selected test questions. A table of expected laboratory results may also be appropriate.

16. **REFERENCES** – Include all outside sources of knowledge and facts used from public and authorized sources.

The authors are encouraged to make a technical outline of their course with the subject broken down into a unique learning module per semester week of the course, with as many supporting knowledge concepts as is necessary to support each module. Each concept should focus on a single idea that is central to the overall understanding of the subject of the module. Here the author should bring to bear all of the media potential possible to present, strengthen, and assess understanding of the concept. The author should carefully plan how to best use text, pictures and illustrations to present the material. Next, having completed this part of the information development, the author should use the "Mimio"® laboratory equipment and explain the concept in the form of a short 10 to 15 minute "streaming lecture". In the CD text, a hyperlink will then give students the option of viewing this short concept lecture for a better understanding from the perspective of the author.

Trained editors can then take the author's contribution and package it into the finished CD text product using Authorware® and the other support programs required to create an electronic text book. The subsequent editing allows a second party to carefully scrutinize the material, correcting grammar, spelling and punctuation errors. The editor then passes the work to a software integrator who electronically packages the final CD textbook. This affords a third look at the material as well as assembles everything into an easily navigated final product.

**SUMMARY OF STUDENT FEEDBACK ON THE COURSE**

To adequately assess the effectiveness of our proposed improvements to the on-line program, we first set out to determine where we are and what needed to change to improve the program. To do this, we talked to numerous students who had taken both on campus classes and on-line courses. We also talked to professors who had taught both. From these discussions, some interesting and enlightening thoughts emerged. Professor Verne Hansen of Weber State University stated, "Having taught both in the classroom and on-line, I have observed that our on campus students are more successful at completing the equivalent courses with better grades then their on-line counterparts by almost a factor of two to one. I conferred with several other of my colleagues who also have taught in the classroom and on-line courses at the same time, and they have arrived at the same conclusion."
We all agreed that **students who are exposed to the subject matter only through the internet and the course text book have a more difficult time understanding and completing the course work than did those students who attend live lectures.** Statistics compiled about those who enrolled in on-line courses as compared to those who enrolled in the same course on campus showed that there was almost a 50% higher success rate among the on campus students using almost any measurement criteria. It is misleading to rely on statistical data when making such a comparisons because many other factors influence the outcome. On-line students may have more extenuating circumstances like difficult work schedules and limited personal resources. The fact still remains that there is a significantly lower success rate among the on-line students than their campus colleagues. In light of this fact, an additional goal of the on-line program must be to raise the success rate of on-line students.

We next interviewed both successful and unsuccessful students and began to note some significant differences between the two approaches to teaching the same material. I compiled a list of ideas, suggestions, and comments gleaned from our discussions and interviews. Some of the factors that might be contributing to the problem are outlined below:

1. **Access to the professor is limited and response back is often slow.** Students complain that sometimes several days may pass before they can get an answer to a simple question.
2. **In some textbooks, key concepts are difficult to understand while the on-line resource material does little to fill in the voids.** This leaves holes in the students understanding. With no other resources to help correct misconceptions or to answer questions, students often become discouraged and disoriented.
3. **Homework examples are often ambiguous and even more difficult to relate to assigned problems.** Sometimes there are no examples at all and nowhere to get help.
4. **On-line students tend to put off doing assigned work until it is often too late to get it in on time.** Generally the written course schedules and syllabi are good, but the less motivated student will put off work when not reminded by someone to meet the schedule.
5. **It is difficult to administer tests that require graphics, pictures, or technical symbols.** The on-line test program is mostly limited to multiple choice and essay questions and does not support scientific symbols or technical script like students must use to solve problems.
6. **Turn around time for grading and returning homework** and tests is often done through the mail and sometimes **takes weeks for students to get feedback** from completed work.
7. **Laboratory assignments are difficult and in some cases almost impossible to do without the equipment available on campus or at some industrial center.**
8. **Internet access is slow and crashes often when trying to access on-line helps placed there by the professor.** If high-level media resources such as video clips or streaming lectures are available, they are often too slow and too difficult to down load for easy access by the students, or demand for high bandwidth media chokes the system.
9. **The on-line course is impersonal and on-line students often feel abandoned and alone.**
10. **When the professor can be contacted by email or telephone, it is difficult to understand the answers to technical questions over the phone or through email.**
A common interest shared by both on-line students and professors alike was that more students succeed in completing the course and being able to apply the material later. The students were reluctant to blame their failures on the program or the professor. Professors understood the students’ dilemma but did not have the time, understanding, nor the resources required to improve their courses beyond the traditional syllabus and weekly reading and homework assignment approach. Everyone interviewed expressed a sincere desire to improve the program and to raise the success rate of the on-line students. **No one doubted the value of the on-line program. The consensus was that it needed to be improved and not discontinued.**

Everyone interviewed had ideas and suggestions of how we might improve the on-line program. Some were very good and insightful, others were reasonable but difficult to implement. No one suggested that nothing could be done. **Some of the suggestions have already resulted in changes in how we offer our on-line courses and have already resulted in improved grades and student work.** Other ideas remain the subject of subsequent and ongoing research outlined in this report.

Some of the suggestions that came out of the interviews with students and professors are easily resolved by good teaching practices and equally apply to the on campus courses. Other suggestions reflect the frustration experienced by students working alone to understand complex concepts with only a written textbook as a resource. I selected three of my on-line classes to serve as a broad based test of the "streaming lectures": CEET 1130 (Introduction to Digital Electronics), CEET 2110 (Solid State Circuit Design and Data Acquisition), and CEET 3050 (Assembly Language Programming and Device Driver Design). To find the time to do the preparations, I took a sabbatical leave from my regular teaching responsibilities and spent the time developing on-line course curriculum. During this time, I developed streaming lectures for the first two weeks of all three classes with written text supplements for the balance of the semester. The results were dramatic. Jay Tuttle, one of the CEET 3050 students, stated that he would not have been able to complete the course without the first two weeks of streaming lectures and the subsequent written text supplements. When the streaming lecture experiment ended after the second week, many students voiced their disappointment, and one of the CEET 1130 students, James Clark, wrote a letter to the director of the WSU on-line program requesting that they find a way to continue the streaming lecture program. During the time the streaming lectures were active on-line, I received only a few email inquiries from students, mainly dealing with homework logistics problems. The quality of work was better, test scores were in the 90th percentile range, and the majority of the class turned in homework and laboratory experiments on time. When the streaming lecture experiment ended, the volume of student email inquiries jumped from two or three a week to over 15 to 20 a day. Test scores plummeted to the low 70th percentile range, and homework began to trickle in. The over-all quality of the course took a dramatic step down. In the mean time, the streaming lectures had noticeably over stressed the Weber State on-line server and telephone bandwidth capabilities, so the answer wasn't to continue with the streaming lectures on-line in spite of their benefit. Because of the rapid decline in productivity, and the student demand that we had created with our experiment, I was forced to produce a subset of Mimio® streaming lectures over the more difficult parts of the course that I copied to a CD ROM and distributed to my students. This action resulted in a proportional increase in the productivity and grades of the three classes. At the end of the semester, fewer then 10% of my students failed to
receive a passing grade. Even though this is slightly lower than on-campus classes, it is a dramatic improvement over the past history for on-line courses. The completed work is also now available for subsequent classes and will eventually result in quality CD textbooks.

LIST OF RECOMMENDATIONS FOR IMPROVEMENT OF ON-LINE COURSES

1. Offer a weekly help session when most of the students in the area can drop in for personal help. (This suggestion was subsequently implemented by most of the CEET department on-line professors and has resulted in a dramatic improvement in assignments completed on time, and in test scores. The main problem with this approach is that help sessions only benefit students who live in the area and can arrange their schedule to attend. Offering help sessions defeats the purpose of offering the course on-line because it becomes another campus course that just meets less often.)

2. Record the lectures for the course and make them available for students to copy or check out. (This suggestion has prompted our research into methods of recording & preserving lectures. A summary of our findings and some effective ways to implement this suggestion has been developed and is included in this report.)

3. Publish more and better examples of how to work the homework problems and laboratory experiments. (This suggestion is also addressed in the body of the report.)

4. Assemble a package of hardware and equipment that students can afford and use to do the laboratory assignments at home. (To implement this idea, student purchase self-contained laboratory trainers and parts kits for several of the courses. These trainers allow the laboratories to
be built and tested anywhere without the necessity of going to the university, purchasing expensive equipment, or going some place that has the equipment available in order to complete the laboratory. This has also prompted our partnership with Orchid Educational Enterprises, Inc., a producer of educational trainers, and a publisher of electronic media.)

Note: OrchEd ® can be contacted at Orchid Educational Enterprises, Inc., PO Box 459, Huntsville, UT 84317, www.orched.com, or by calling (801) 745-0212.

5. Outline those parts of the textbook that are most important and emphasize what students need to know. (This suggestion is also addressed in the body of the report.)

6. Provide students with a better way to track and assess their personal progress. (Weber State University On-Line has addressed this problem and has since implemented several innovations that show a great deal of promise in helping students track their personal progress. One of these is the web portfolio system that, when properly used, will give students a direct look at what the professor has recorded for each student.)

7. Maintain more contact with the student. Remind the student that they are enrolled in the course and that work is expected. (WSU has provided the vehicle through on-line chat rooms where an interactive web meeting with the professor can be setup on-line at a particular time. Students and professors can get together to discuss the material anywhere on the Internet. Some thought and research is presently investigating how to make this interactive. Our research for this grant has suggested some methods of “live conferencing” that can allow the professor to place a visual white board and audio link out on the web during a web help session. This remote classroom could replace the now on campus help sessions and still allow two-way interaction between students and professors in all parts of the world. In this manner students can remotely view a white board and listen to the professor explain his answers live on-line.)

8. Present the material to the students in ways that involve more of the senses. As much as possible, emulate the classroom lecture experience. (The major part of the grant research addresses this very suggestion and outlines a way this can be done in a very effective way.)

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BIOGRAPHICAL INFORMATION

Dr. Robert A. Summers received a Bachelor of Science degree in Electrical Engineering from Brigham Young University in 1972. He received his Masters of Electrical Engineering degree from the University of Washington in 1979, and his Doctor
of Philosophy degree in Electrical Engineering from the University of Idaho in 1985. Dr. Summers worked as an engineer for Boeing, Martin Marietta, EG&G, and NASA. He worked like the Space Shuttle, the B1 Bomber, the MX Missile, The Super Collider, and the Nuclear Power Reactor Loss of Coolant test in Japan. As a private consultant, Dr. Bob helped design the present television encryption system used for satellite television and helped solve many design problems for companies like Sperry, the Department of Defense, and Cincinnati Microwave. Doctor Summers started teaching Electrical Engineering at the University of Washington, working first as a graduate assistant and then as a lecturer for two years. From there he went to the University of Idaho where he worked as an assistant professor for four years while he finished work on his Ph.D. He accepted a job as engineering manager at EG&G's Utah office in Ogden, Utah and eventually found his way back into academia as a Professor of Electrical Engineering Technology at Weber State University, where he has worked for the last 14 years. Dr. Summers holds several patents and has a background that spans thirty years, and follows the development of modern integrated circuits and digital electronics.