Abstract - New information and communication technologies have become major resources for teaching and learning in higher education. Technologies have multiple capabilities to support different instructional strategies and provide an efficient way of delivering course material and improving comprehension. Unlike a classroom discussion, where students and instructors are bound to course packs and books, online discussions actually enhance student learning by the vast number of additional resources that are easily accessible, important, and up-to-date. Yet administering tests to distance learners presents unique challenges. Giving a “closed-book” exam on site, for example, involves commuting or special arrangements with proctors local to each student. In a distance-learning environment, this can cause inconveniences that overcome the benefits of students’ taking classes on-line. This paper presents an idea for allowing closed-book exams local to the student, while reducing the likelihood of cheating to equal that of the traditional classroom environment. It employs a network of audio and video communication-enabled personal computers capable of alleviating many of the issues mentioned above. Specifically, it implements a Classroom Local Area Network as a beginning concept/prototype development and then broadening these concepts to the distance learner.

INTRODUCTION

This project implements visual systems to and from the instructor’s station and to and from the student’s workstation, whether local to the instructor or remote via the internet. The student workstation camera transmits the current status of the student’s laboratory project to the instructor and/or the class, as the instructor chooses. This paper summarizes the hardware aspect of achieving this.

Traditionally, in a distance-learning-over-the-internet scenario, the student is not allowed to take closed-book tests online. The concern mainly involves enforcing integrity. To ensure that the test is administered in the manner in which the instructor intends, a proctor near the student’s location must be recruited and certified. The Florida Community College at Jacksonville has commonly recruited proctors and sent tests to remote testing sites as a method of securing test integrity [3].

This method, however, provides a discontinuity to both the distance learner’s and the instructor’s convenience and experience, since three weeks’ time must be allowed for the process.

A method of allowing the student to take a closed-book examination from the site of his or her choosing is herein proposed. Web cameras are inexpensive and compatible with most recent personal computers. There are several models on the market that retail for less than most collegiate textbooks. Among other advantages of the student’s sending video back to the university server, the camera can be used to ensure that the student is taking his/her own test, and in an honest manner.

SYSTEM CONSIDERATIONS

Hardware for video conferencing systems over the internet is becoming feasible financially for the home-bound or dorm-room student. According to a 2002-2003 Robert Lembke survey [4], 87% of a sample of college students already has the basic personal computer needed for video conferencing. Moreover, not only are digital audio/video hardware prices falling, but installations are becoming nearly trivial due to the advancement of personal computer operating system technology. A web camera can be had for less than the price of a textbook. Both Windows and Macintosh operating systems integrate applications that allow video and audio chatting, as well as video conferencing and e-mailing video files immediately after capturing the video directly into the PC. Furthermore, web communication applications, such as AOL Time-Warner’s Instant Messenger and AVM Software’s Paltalk, support any combination of video, audio, and text communications [8]. PCs are expected to soon ship with a video camera bundled or built-in just as microphones and speakers have evolved to integration with PC systems in the past. In 2004, a PC configurable video camera (web-cam) can be had for around $20 to $30 USD (Logitechforless.com). For example, Circuit City retail stores have Logitech models retailing between $30 USD and $100 USD. Commensurate with price, a standard web-cam includes only a lens and Charge Coupled Device (CCD chip) to serial output, but zoom, pan, manual focus, picture-and movie-editing software, and/or other special software are available options. Microsoft Windows XP, for example, now integrates a step-by-step wizard into the Windows Messenger application setup that identifies and/or loads the appropriate drivers like camera and microphone for the user’s hardware [1].

Here is the proposed equipment to allow a more “being in class” experience. With such technology, the distance
classroom can become so real that even hands-on projects like electronics laboratories can be accomplished.

PC Minimum requirements for a CCD video camera depend on the hardware peripherals and associated software. For example, in 2003, Logitech recommended as little computing power as a Pentium 3, 500MHz Celeron, or AMD Athlon processor, 64MB of RAM (or more if PC operating system requires it), 200MB of hard drive space, full duplex sound card capability (for bi-directional audio conference), and USB port. Considering that PCs are currently shipping with many times that capability, it is evident that the time is very near for widespread use of web-cams. In this classroom application, it is assumed that near real-time video frame updates are acceptable. Mention of video quality is necessary due to network (internet or otherwise) tradeoffs including bandwidth vs. video frame rates and resolution [1].

SYSTEM OVERVIEW

The system overview discusses both distance-learning and in-classroom electronics laboratory sessions running at once. The instructor lectures live.

Suppose there are three participants, an instructor plus two students. One student is connected with the instructor via a hub, or local area network (LAN) switch (or hub), and the other student is connected with the instructor via the internet through a server, which is also on the LAN. If the software is configured as such, the students could interface with each other through the server as well. Peripheral devices are connected to each participant’s PC (CPU). Students on the LAN are connected to the instructor and network server via a network hub. Students’ PCs are outfitted with a peripheral microphone and web-cam (some cams have an integrated microphone) for audio and video input. Students’ laboratory (electronics) project board may interface with the CPU if it is of a software-programmable nature. A connection between “Hands-on project” and “web cam” allows the camera to take video of the physical project board. Thus the instructor (or other students) views the current lab activity, such as breadboard circuit wiring. As far as peripherals, the students connect a web-cam, microphone, video monitor, and their project board to their CPUs. The instructor’s CPU also interfaces with a microphone and video monitor, but additionally outputs to a “Big Screen Projector” and may use a higher quality video camera in lieu of a web-cam. The instructor will also require limited access to the university’s student I.D. secure database if the remote testing administration idea, from above, is to be implemented.

SYSTEM COMPONENTS

For greater understanding of the system, a description of each type of device used in the system follows.

- **Student CPU**: This is the personal computer (PC) residing at the student’s desk, whether local to the instructor, or abroad. The student’s PC should meet the minimum performance requirements for operating a web-cam, sound card, microphone, and video monitor, as mentioned above. PCs quadrupling the minimum requirements are inexpensive from the low-end of most product lines, such as those from vendors Dell or Gateway. Dell.com advertised such a desktop computer without monitor for only $349 in November, 2003.

- **Instructor CPU**: This is the personal computer residing near the instructor’s lecturing location. It houses the central main processing unit that processes information both to and from the peripherals. This machine differs from the student’s CPU in terms of its hardware requirements so that functionality and performance will not cause any data throughput bottleneck. The instructor’s CPU should be capable of accepting and transmitting high-quality video in real time. In addition, the throughput capability of this signal will have a direct bearing upon a student’s perception of the school as a whole. In addition to high-quality video, the instructor’s CPU must send video signals to both a standard computer video monitor and a projection screen system. Other than these requirements, the instructor’s CPU is very similar to the student’s.

- **Network Hub (or switch)**: This is the hardware device that allows several nodes (PCs) to share a network connection. Computers that are in the same room often multiplex (share) a connection to the local server via a hub. Hubs cost less than switches, but switches make it possible for several users to send information over a network at the same time without slowing one another down, according to Jeff Tyson on the How Stuff Works website [5].

- **Video Monitor**: This is the standard video monitor for the individual user. It is where video is displayed to the user.

- **Big-screen projector**: This is the method of projecting a large image in the front of the physical classroom for communicating to students physically in the same room with the instructor. For example, the instructor might demonstrate a laboratory procedure while streaming video to the big-screen and the internet simultaneously. It might also be utilized to show the work or video of any other student in the session.

- **Speakers or headphones**: These are the transducers that translate electrical signals to acoustic signals. They allows users to hear audio being sent by the instructor or another student. The speakers or headphones are connected from the sound card. The sound card converts the digital signals from the computer software to analog, pre-amplifies them, and sends them to both an external amplifier and speakers, or a headphone set.

- **Microphone**: This is the transducer that translates acoustic signals to analog electrical signals. It is connected into a sound card that is plugged into the CPU. The sound card amplifies the low-level audio signal and converts it to a digital signal. This signal is now usable by software and is available for transmission over any digital network. Some web-cams include an integrated microphone, eliminating the need for a separate transducer.
or sound card. In this case, the analog audio data is digitized within the camera and sent to the CPU along with the video signal via the USB port. It is recommended, however, that the microphone be located very near the person’s mouth to send a signal clear of background noise and echoes. A headset-style microphone can be a good quality, yet inexpensive alternative to a microphone that must be placed far from the user. The instructor should employ a wireless lavaliere microphone to free her from the confines of being wired to her CPU. A lavaliere microphone has an omni-directional pick-up pattern, but the attachment of the small microphone element to the user’s lapel creates a more directional condition. Directionality of the microphone is important so that only the desired signal is transduced and noise is rejected. The result should be that only the desired signal is sent to the sound card for processing. To make the most of getting a good, clear, intelligible signal into the CPU and out to the network, special acoustic treatments should be added to the room where necessary in order to reduce echoes back to the microphone which would cause out-of-phase audio input, and thus a less intelligible signal.

- **Code/decode interface (codec):** This could be either a device, or an implementation in software residing at each users’ CPU. Data encoding and decoding are necessary to compress video and audio in an attempt to send only data that is needed for understanding, and no more. Thus, efficiency of data transmission is the goal. In H.323 standard desktop videoconferencing systems, the codec typically resides on an interface board or in a software application. In H.323 group conferencing systems, the codec is most likely an interface board itself (you buy the PC) or is part of a turn-key system that is possibly proprietary but most likely PC-based [1].

- **Digital Video Camera (Web-cam):** This is the peripheral device that is making the virtual classroom feasible. The web-cam is simply a digital camera that makes an image at its lens available to the USB port. A piece of software connects to the camera and grabs a frame from it periodically. For example, the software might grab a still image from the camera once every 30 seconds and send it over the internet to a server on a particular local network, making the images available to any node (PC) on that network, according to Marshall Brain on How Stuff Works.com [6]. The key component in the web-cam is its charge coupled device (CCD). When light is focused on the exposed silicon pixels on the CCD chip, each pixel accumulates charge proportional to the light’s wavelength and exposure time. This charge is amplified one pixel at a time, and converted to a voltage. It is something like light intensity being stored as a number [2]. While the video from student to professor must be of acceptable quality, the video from professor to student should be exceptional to help keep perception of the school positive. To accomplish this, the classroom should be outfitted with a professional or semi-professional digital video camera, lighting, and backgrounds. Though operation is approximately the same as the simple web-cam, improved optics, as well as improved CCD technology will allow the transmitted video to be as clear as possible. According to Day and Norton on TechTV.com, a good light source will do more for the quality of the video than anything else [7]. At a minimum, lighting in the room should come from three sources. Diffuse illumination of the top, side, and front of the subject will present a clear image to the video recipient.

- **Hands-on project board:** This is the laboratory experiment itself. It could be a physical experiment such as performed in physics, or a combination of virtual and physical, such as in a microprocessor class. The diagram shows both a line to the web-cam and to the CPU. This describes the case where both a computer-interfaced project (e.g., a microprocessor) and/or a physical project (e.g., a breadboard circuit) are utilized.

- **University Student ID Database:** This is the database maintained by the university information systems administrator and contained on a secure server. The database is included in the diagram to represent the possibility of the instructor’s accessing it in the case of verifying a student’s identity. The instructor might simultaneously pull up the student’s picture identification from the database, and view the student via his/her web cam.

**VISION OF THE SYSTEM**

The vision of the system is harmonious integration of distance-learners, classroom participants, guest speakers, and the instructor.

The instructor is teaching class with a camera focused on him and/or the project that he is demonstrating. Either subject is broadcast simultaneously to the local big screen and to each student’s video monitor. The instructor has selective access to any particular video camera on the system. He can rebroadcast any person’s web-cam to the students (participants) or to the big-screen projector in the local classroom. This allows for interaction between all parties. For example, if one student cannot get her laboratory project to work properly, the instructor might rebroadcast video of her project to the other students. The other students would have opportunity to participate in debugging that student’s project. The collaborative effort would benefit all in terms of gaining experience from solving a particular problem. Similarly, an instructor could work one-on-one with a student whether local or remote, even overseas. Some communications software, such as AVM’s Paltalk, include capability for multiple video (up to six video windows simultaneously), audio, and chat [8]. Cooperation is very easy with existing technologies. Also, as outlined above, the instructor might use the system’s capabilities to administer a closed-book exam.

The student has the capability to send video of herself or her project at any time during a classroom session. This allows the instructor to not only grade her work, but also help
with debugging, make suggestions, or just encourage with a compliment. When an issue with a lab is encountered, the distance-student can get help as if she were in the local classroom with an instructor or other students.

CONCLUSION

With the infusion of current technology, Engineering Technology curriculum can be enhanced. Web cameras are inexpensive and compatible with most recent personal computers. Technology outreach can be achieved by infusing hands-on courses to the ranks of distance-students. Several weaknesses of current distance-learning environments can be overcome. Specifically, it is now possible to teach hands-on courses over the internet, as well as administer closed-book exams without mailing tests or recruiting proctors, all-the-while maintaining the integrity of university-level programs.

REFERENCES


