

Adapting Pervasive Learning Technologies to Machine Vision Course

Chi N. Thai
University of Georgia
Biological & Agricultural Engineering Department
Athens, GA 30602-4435

Abstract

An IT architecture suitable for teacher-centered active-learning approaches is proposed herein, using gigabit network and video conferencing equipment as well as network control and collaborative learning software. The chosen software approach supports interaction and collaboration features in the lecture delivery task, between teacher and students, as well as between students, within as well as outside of the classroom. This report describes the integration of two collaborative learning software packages "NetSupport Manager" and "Silicon Chalk" in the delivery of an Applied Machine Vision course whereas lecture, demonstration and laboratory activities are merged seamlessly. The system performance for a classroom having 12 student PCs and 1 teacher station is reported herein. This class was offered in Spring 04 but unfortunately no students enrolled for this class, thus we do not have student feedback on this instructional approach at this time.

Introduction

Several reports from the National Research Council^{1,2} advocated the adoption of Information Technology to improve student learning at the high school and university levels, but Hilton² also acknowledged that "Information Technology (IT) is changing at a breathtaking pace, making it virtually impossible to accurately predict its future impact on teaching and learning in undergraduate science, mathematics, engineering, and technology education". Maeroff's³ survey showed that "A Classroom of One" is just around the corner, and Raschke⁴ predicted that the University, as we know it, will be "deconstructed" in the near future as learning shifts from a teacher-initiated orientation to a more active role from the student. For this purpose, the National Science Foundation had been funding for more than a decade 7 Engineering Coalitions (Academy, ECSEL, Foundation, Gateway, Greenfield, SUCCEED, Synthesis) for researching and disseminating better methodologies for engineering education (http://www.foundationcoalition.org/home/foundationcoalition/engineering_coalitions.html). Recently, we also have Project Catalyst from Bucknell University to train engineering faculty for problem-based learning (<http://www.departments.bucknell.edu/projectcatalyst/>). DiSessa⁵ and Shneiderman⁶ described innovative computing concepts and technologies better suited for human needs, especially in science and engineering education. Interestingly, Shneiderman's active learning approach goes beyond the academic realm to extend to the corporate community or civic

network as the ultimate realm for application of any education process considered as a human activity. The most surprising finding is that all these concepts and projects have a common paradigm in the Constructivist viewpoint of learning (Bransford et al.⁷) which has one basic tenet that the learner constructs his or her own knowledge. However on the other side of the coin, in a recent study, almost 25 percent of first-year engineering students reportedly study less than 10 hours per week outside of class, with only 12 percent saying that they spend more than 25 hours on school work (Wankat and Oreovicz⁸), showing rather clearly that students are not yet ready to be responsible for their own education. Furthermore, most of current engineering faculty were exposed to or trained (if at all) in the standard lecture format of information delivery, so most of them are also not ready for active learning methodologies.

Over the past 2 years, the Biological and Agricultural Engineering Department at the University of Georgia had been engaged in developing and adopting pervasive learning technologies with the goal of engaging our students into an active learning mode inside and outside the classroom. This report describes the integration of two collaborative learning software packages "NetSupport Manager" and "Silicon Chalk" in the delivery of an Applied Machine Vision course due to go on-line in January 2004. This Machine Vision course (ENGR-4550/6450) was already taught once in Spring 02 using standard classroom oral lecture techniques with PowerPoint slides and paper copies of the slides distributed to students for notes taking. The specific objectives were:

- 1) Design and implement a computer network architecture suitable for active learning approaches.
- 2) Implement a software approach that supports interaction and collaboration features in the lecture delivery task, between teacher and students, as well as between students, within as well as outside of the classroom.

Rationale for Selected Approach

About half of the BAE teaching faculty uses PowerPoint slides regularly as the information delivery tool, while the other half finds the standard chalkboard adequate for their needs. At this time, our students are also nowhere near ready for a full-blown student-centered problem-based learning approach, thus the author's goal was not to design a solution that was too far from the possible adoption reach of the majority of the faculty and students, and also to implement it in incremental steps. The adopted solution was then "teacher-centered" with some elements of "interaction" and "collaboration" between teacher/student and student/student. The Constructivist paradigm was also adopted because it is the currently dominant school of thought⁹ (at least in the U.S.A. and Western Europe).

Description of Instructional Facilities

The Spring 04 Machine Vision course will be taught in the BAE Collaborative Distance Education (CDE) Laboratory that was developed using Student Technology fees and departmental funds. It was operational in Summer 2003 and currently has 30 workstations for students and a teacher station connected to an isolated 1.0 Gbps LAN with direct fiber

connection to the campus gigabit backbone. Thai¹⁰ provides the technical details for the design of this lab that are summarized below for the reader.

A) In-class Interaction and Collaboration Features

To achieve the data sharing and remote control features needed between the teacher station and the 30 student stations, we adopted a software suite called NetSupport Manager (NSM-V.8.1) which has 2 components: NetSupport School (NSS) and NetSupport Control (NSC). NSS is deployed on local student and teacher PCs. NSS & NSC use a client-server architecture and TCP/IP protocols, and the cost is about \$50 for a one-time license fee per PC installation with academic discounts. Some of the main features of the NSS component are as follows:

- 1) The teacher can "Share-Watch-Control" each student PC on a one-on-one basis. This is used for quick response to student difficulties.
- 2) The teacher can "Show" his or her PC application to all or selected student PCs.
- 3) The teacher can "Exhibit" a selected student work to the rest of the class, or organize the class into sub-groups with assigned group leaders.
- 4) The teacher can send out instant surveys to check on the class understanding of concepts being presented (Yes/No answers).
- 5) Facilities for File Transfer, Distribution and Retrieval, and Video Playing are also available.

NSC is deployed only on the teacher station, allowing it to reach outside of the local area network into the World Wide Web to bring in off-campus facilities if needed during class and for Distance Education purposes (see Thai et al.¹¹). This lab is also equipped with a Tandberg 880 video conferencing system for invited guest lectures whenever appropriate.

The second facility is the Spectral Imaging (SI) Laboratory that is described in details in Thai & Upchurch¹². This lab consisted of a Web/FTP server and 2 completely equipped test stations designed to allow students to access the test stations from anywhere in the Web to perform their laboratory assignments in spectrometry and machine vision techniques without having to be physically present in the laboratory, but without losing the touch and feel of actual hands-on experimentation. This system was partially funded by the UGA Learning Technologies Grant program and is operational since January 2002 and has good performance even from modem connections at 56 Kbps and 60 miles away. During Winter 02 semester, 15 UGA students were enrolled in this Machine Vision class which was first offered using traditional methods: in-class PowerPoint lectures and demonstrations, along with homework and in-class tests for assessment. The students were using this web-enabled lab from 6 AM to Midnight daily, the log-on times were from 1 to 3 hours, and 24% of the log-ins was from student homes.

Figure 1 shows the interconnections between these 2 facilities that are best explained by describing a typical class session:

The instructor logs on the teacher station which desktop is projected onto a screen for all students to see. The students also log on to their individual PCs. Next the instructor starts NetSupport School (NSS) to establish computer links to each student PC and requests each present student to enter his or her name. The instructor can then start any Windows applications such as PowerPoint or Excel, and share them via the screen projector or send

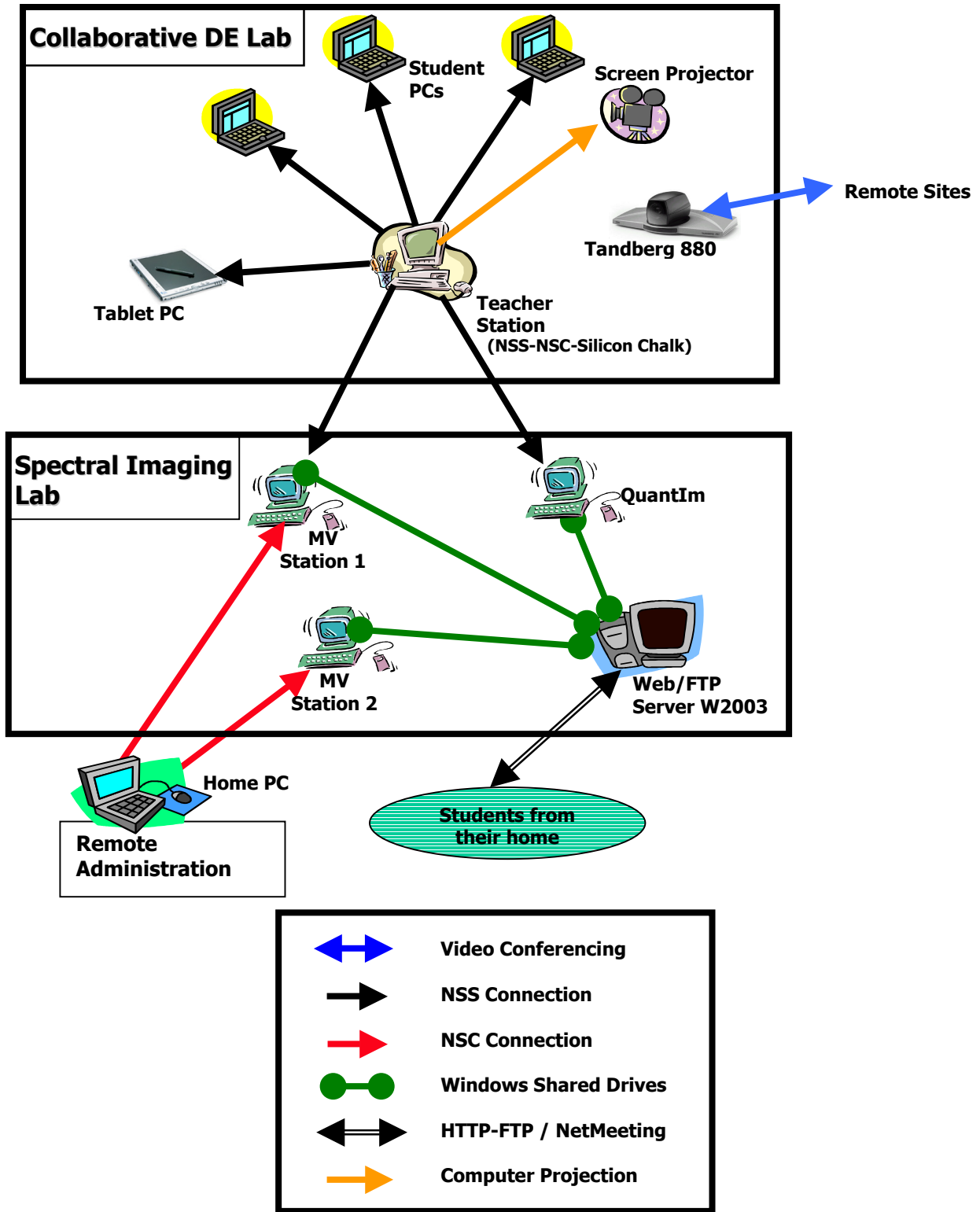


Figure 1. Information Flow between CDE and SI Labs during classroom instruction.

them directly into each student PC monitor, and deliver lectures as normal. If needed the instructor can also share a Tablet PC and/or a FireWire camera for hand-written notes or doing a demo with props. When explaining how to use test equipment that reside in the Spectral Imaging Lab, the teacher can also use NSS to remotely control the machine vision stations physically residing there and thus share them with the students in the CDE Lab. **Thus lecture, demonstration and laboratory activities are merged seamlessly with this scheme.** Furthermore, the software called Silicon Chalk (to be described in a later section) is also installed on all teacher and student PCs to allow the capture of all the above in-class activities along with the teacher audio comments into an MP3 file that the students can later review off-line. During off-class times, the students can also perform their lab assignments from home by logging into the Web/FTP server, while the teacher can remotely administer the vision equipment during off-business hours as needed, using NetSupport Control (NSC) software.

B) Outside-of-class Mobility and Connectivity Features

Although the previous section clearly demonstrated that the NetSupport Manager suite can provide high levels of Interaction and Collaboration within the classroom, we readily recognized that, for students, the "learning" time in-class is very small as compared to the time spent outside the classroom during which we wanted to motivate students to achieve their own learning goals. We also noticed that although, in-class, students can follow along with the teacher complex procedures involving keyboard and mouse inputs, shortly afterwards and outside of class, students had difficulty remembering lengthy procedures. To alleviate this problem, we had used packages such as RoboDemo (<http://www.ehelp.com>) and Camtasia (<http://www.techsmith.com>) to create narrated tutorials that are publishable on the web such as this one (http://www.engr.uga.edu/~thai/KUProject/exp1/Tutorial_2/Tutorial2.htm), showing students how to perform a spectrometry experiment. RoboDemo yielded a good final product but it took a fair amount of time to prepare one tutorial and Camtasia sped up this process quite a bit, however both of them yielded products that were static as students could not modify them for personal needs. In his book "Persuasive Technology", Fogg¹³ recommended using Customization, Mobility and Connectivity (among other technologies) to increase "Persuasion" for the computer users (students in our case), that is to motivate users to achieve their own goals. Currently, the only product on the market that is designed specifically with this approach in mind is Silicon Chalk (<http://www.siliconchalk.com/features.htm>). Coatta¹⁴ narrated the flow of different learning activities in a typical day for a student using Silicon Chalk from in-class notes taking, to working cooperatively with fellow students on a common web-based project, to updating one's own personal notes and so on. For our current needs, we use a lab-based installation with extra student licenses for home use bought by the department for them, as the number of students is usually small for this class (around 15), and also because Silicon Chalk has not yet finalized their financial model for various licensing modes at this time. The cost is \$33 per PC installation and licenses need to be renewed every year.

As we plan to use Silicon Chalk (peer-to-peer and using UDP protocols) together with NetSupport Manager (client-server and using TCP/IP protocols), we had some initial concerns whether they are compatible with each other, but we are glad to report that they work together

seamlessly. However we must report that the current version 2.5 of Silicon Chalk does not work with a dual-CPU PC, nor one with the recent Pentium IV with hyper-threading feature. In these situations, the standard Windows OS (2000 or XP) is modified in such a way that Silicon Chalk cannot find the network card and therefore cannot communicate to the other PCs in the same network.

During a typical class meeting, the teacher would need to wear a wireless microphone interfaced with the teacher station sound card and start NSS to link the teacher station to all student PCs along with other "instruction" PCs as needed (Tablet PCs and machine vision stations located in the Spectral Imaging Lab) (see Figure 2 for a view of the NSS main window). Next teacher and students would start their own version of Silicon Chalk, then students would essentially wait for the teacher to start the recording session. At this point, the teacher would start PowerPoint and load the lecture slides of the day, and any other Windows applications needed for instruction. The teacher is now ready to start the class, i.e. his own recording process, at this time the teacher station would send messages to student PCs signaling that they can join in the class (i.e. start their own recording process on their local PCs, if they want to). At any one time, Silicon Chalk can only record up to 2 live Windows applications and one notepad (along with teacher narrations of course). Figure 3 is a playback screen of a Silicon Chalk recording showing two Windows applications: Stella (being minimized on the top left), an NSS session, in the main view, showing how to perform a spectrometry experiment "live" on a selected machine vision station located in the Spectral Imaging Lab and a little notepad for notes.

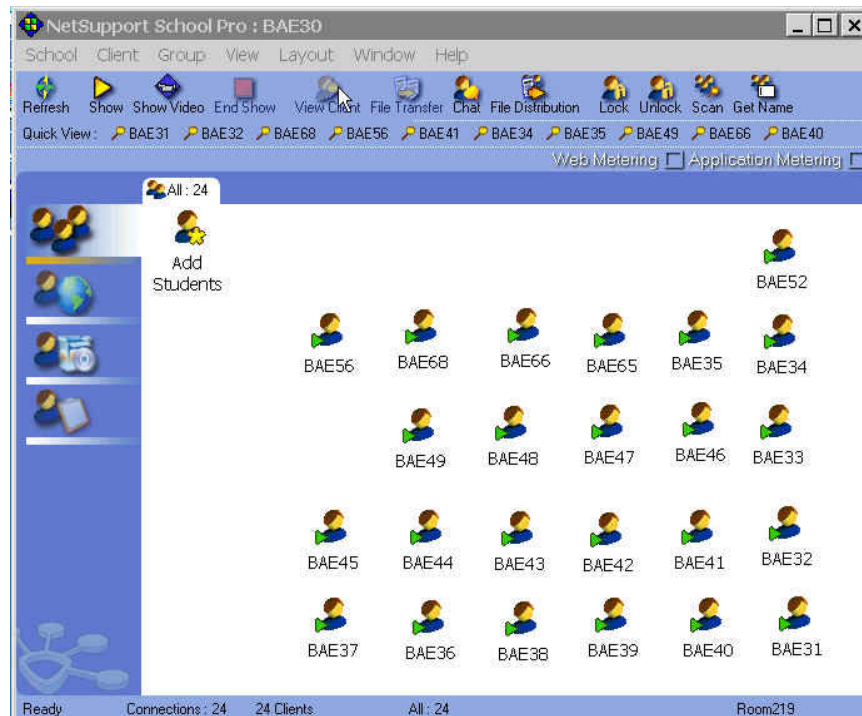


Figure 2. Main Window of NetSupport School Software

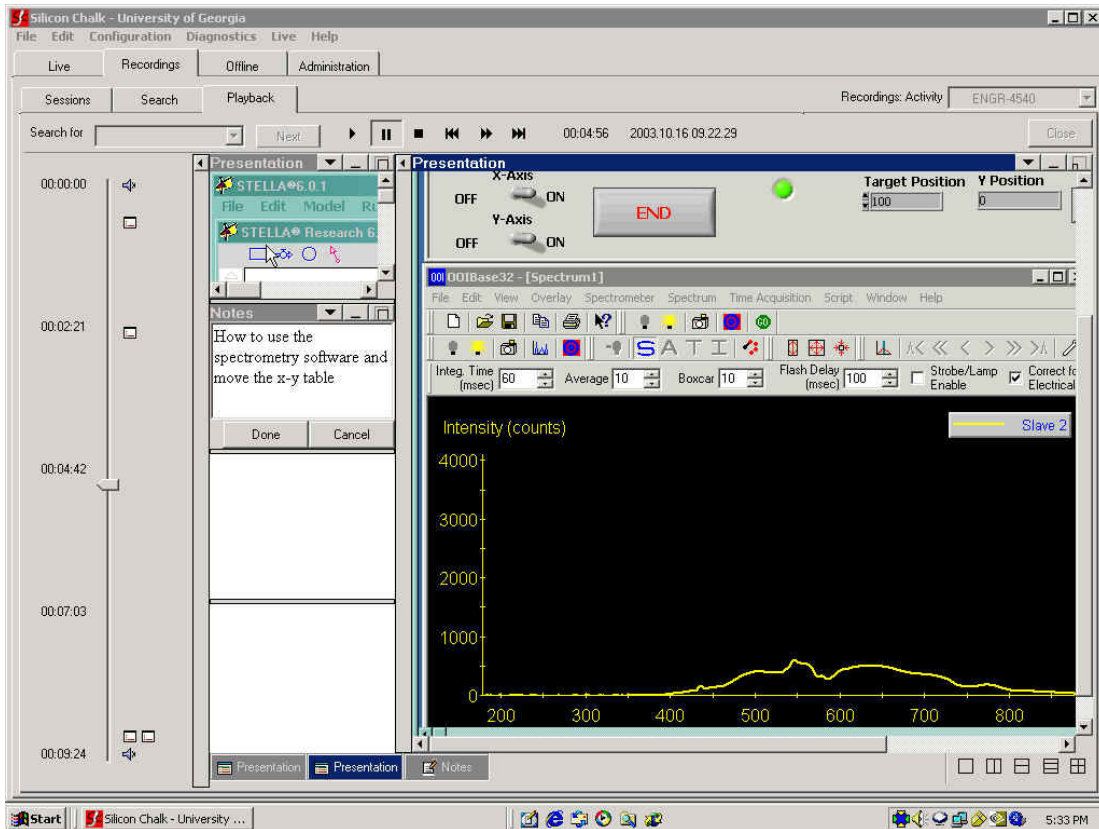


Figure 3. A typical recorded Silicon Chalk Session

During a Silicon Chalk session, each student is free to add their own notes as needed on their PCs or leaves the session any time. Silicon Chalk has an interesting feature that allows late students to catch up on their own recordings so that they still have the complete class session at the end of the period. Usually in addition to a PowerPoint slide show, the teacher would use NetSupport Manager to demonstrate remote access and control of networked spectrometry and machine vision equipment that are located in a different physical location. These demonstrations can also be recorded as another presentation stream inside Silicon Chalk. The teacher can also use NetSupport Manager to interact directly with chosen student PCs to help with any problem that the students may have during practice sessions, or to exhibit a chosen student work to the rest of the class. After classes, students need to copy their recordings (MP3 files) to a CD-R or Zip disk to bring home. When students review their personal recordings outside of class, they can still add new notes into the previously recorded session. Both software packages also offer many other on-line tools, such as for surveying/polling, chatting/questioning, quiz distribution and evaluation, which will be evaluated for their performances.

Project Implementation

This Machine Vision class was scheduled for Spring 2004 semester, but unfortunately no students enrolled in this class, thus we cannot report on student feedback about the effectiveness of this instructional approach, but we did test our system on a medium-sized classroom with 1 teacher station and 12 student PCs. All PCs were identical and had a plain Pentium IV CPU at 2.53 GHz with 512 MB of RAM and a network card working at 100 Mbps. They were all connected to a 100 Mbps Ethernet switch that also connects to a remote computer controlling machine vision equipment on a 10 Mbps line. The student PCs were on Windows 2000, while the teacher station was on Windows 2003 Server Standard Edition. Our full operational condition was such that Silicon-Chalk was broadcasting simultaneously to all 12 student PCs two Windows sessions (one with PowerPoint slides and the other remotely controlling machine vision equipment via NetSupport Manager), along with an audio stream containing the instructor narrations, and while all 12 student PCs were under the control of NetSupport School software. At this point, Windows Task Manager reported that 439 MB of RAM were used and that the CPU usage was about 38-40%. Whenever we switched to a new PowerPoint slide, the CPU usage would momentarily jumped to 52% then settled down back to 38-40%.

Conclusions

Through the use of pervasive information technologies, we have shown that everyone can now build an engineering instructional system that allows learning to happen at different times and in different contexts, that in a way makes the teacher available 24/7 at the students beckoning. There are some interesting and new issues like copyrights of the recordings: do they belong to UGA, the teacher or the students as everyone involved has some parts, great or small, in the recording itself? So for now, practically all barriers are removed for the students in the mechanics of the delivery of the lecture/lab session, then would the students spend more time studying and learning or would they just let the recordings gather dust and just review them the night before a test?

BIBLIOGRAPHY

1. Pritchard, G. E. (editor). 2002. Improving Learning with Information Technology. National Research Council. National Academy Press, Washington D. C.
2. Hilton, M. (editor). 2002. Enhancing Undergraduate Learning with Information Technology. National Research Council. National Academy Press, Washington D. C.
3. Maeroff, G. I. 2003. A Classroom of One. Palgrave-MacMillan Publishers.
4. Raschke, C. A. 2003. The Digital Revolution and the Coming of the Postmodern University. RoutledgeFalmer Publishers.
5. DiSessa, A. A. 2000. Changing Minds. MIT Press.
6. Shneiderman, B. 2002. Leonardo's Laptop. MIT Press.
7. Bransford, J. D., Brown, A. L., and Cocking, R. R. (editors). 2000. How People Learn. National Research Council. National Academy Press, Washington D. C.
8. Wankat, P. and Oreovicz, F. It's About Time. 2003. ASEE Prism, V. 13, No. 1, p. 44.
9. Bennett, J. Teaching and Learning Science. 2003. Continuum Press.
10. Thai, C. N. 2004. Development of a Collaborative Distance Education Classroom. Computers in Education Journal (Vol. XIV, No. 1: pp. 65-75).
11. Thai, C. N., Morita, K. and Iwasaki, K. 2004. UGA-Kagoshima University Distance Education Facilities. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition.
12. Thai, C. N. and Upchurch, B. L. 2004. Tele-Experimentation for Machine Vision Course using NetMeeting and LabView Software. Computers in Education Journal (Vol. XIV, No. 1: pp. 2-11).
13. Fogg, B. J. 2003. Persuasive Technology. Morgan Kaufmann Publishers.
14. Coatta, T. 2002. Silicon Chalk and Pervasive Learning. (<http://www.siliconchalk.com/Documentation/White-Paper-Day-in-Life.pdf>)

BIOGRAPHICAL INFORMATION

Chi N. Thai

Associate Professor, Biological & Agricultural Engineering Department, University of Georgia. Research interests are in the development of optical sensing systems for stress and disease detection in peanut and cotton plants and for evaluation of quality of agricultural products using standard UV-VIS-NIR spectroscopy and Multi-spectral Imaging, and in the development of distance learning technologies and methodologies.