Distance Learning in Thermal Design of Electronic Systems
The IEEE/NSF Project

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ABSTRACT

A three-year collaborative effort initiated by three institutions has resulted in a new paradigm for distance learning in rapidly evolving technology areas, such as electronics packaging. From the start, the team emphasized the use of multi-media technology for creating and disseminating internet delivered, re-configurable, shared modular educational materials. These modules could be used in a stand-alone fashion for re-training, or embedded in existing courses in various curricula. Using these modules, the first offering of a one semester graduate course on thermal design of electronic systems was made during Spring 1999. This included participants not only from the three original universities, but also from the industry and other universities. This course was taught once a week for three hours, live over the internet. In addition, course materials asynchronously available on the web included Power Point slides of the notes, streaming video, computational codes and virtual laboratory tours. During the second offering of this course during Spring 2000, a number of additional features have been implemented, including expanded participation and greater collaboration. This paper will concentrate on the lessons learned from teaching the second generation of this course. Ongoing efforts involving module standardization will also be described.

INTERNET BASED LEARNING OF EVOLVING TECHNOLOGIES

The objective of the three-university team involved in this project was to demonstrate effective internet based models for global learning of electronics packaging. The following unique needs of this subject area guided the development format of the educational materials:

- Modularity
- Rapid reconfigurability
- Multi-media content including text, visual and audio features
- Layered hierarchical structure of modules, with hypertext links and "mouse-over" features for increasing detail
- Any-place, any-time availability of the modules through the internet

A number of modules to satisfy the above needs was prepared by the three university team. Using these, a one term graduate/senior undergraduate course was offered during Winter 1999. In addition to the asynchronous modular materials described above, the course also included a three hour synchronous segment each week. This was used to provide explanations of the asynchronous materials, as well as to discuss home work problem solutions. An additional key feature of the course was case studies by various student groups. The case studies were introduced during the synchronous segment of the course. Typically, a three week period was provided to each student group (2-3 students) to come up with a solution to the case study problem. Each group presented its solution subsequently to the entire class during a synchronous broadcast. Student groups located at four different geographical locations provided their comments during these presentations. Additional details on the first offering of this course are provided by Joshi et al. (1999).

THE SECOND INTERNET BASED THERMAL MANAGEMET COURSE OFFERING

Using the success of the initial 1999 course, a second offering with considerably expanded participation is currently in progress. A total of forty students from the three institutions are enrolled in this effort during Spring 2000. Additionally, some parts of the course will include participants from State University of New York, Binghamton and IBM. As in the previous offeing, the course consists of both *synchronous* and *asynchronous* components. The former is in the form of two 75 minute live internet delivered lectures each week. The three institutions are sharing the delivery of these lectures. A significant part of the synchronous class time is spent in the presentation of homework and case study solutions and a review of these by other participants. The asynchronous web based archive includes a combination of on-demand accessible materials such as Power Point slides of lectures, streaming video of lectures from prior offerings, computer codes and case study solutions from prior years. Key aspects of the classroom hardware and the local administration of this multi-institution course are next described.

The Internet Videoconferencing Facilities at Auburn University

Videoconferencing assistance is provided for this class (MECH 591) by the Instructional Media Group. Services include the use of a 24 seat classroom equipped with a VTEL 3200 videoconferencing unit capable of both H.320 and H.323 communication protocols. The unit consists of three 32 inch monitors, presenter and student microphones, three cameras (two remotely controlled and one document stand camera), with ancillary equipment including an applications computer, voice phones (2), fax, video player/recorder, broad bandwidth internet connections for conferencing unit and applications computer, T1 and ISDN telephone lines (3) and an LCD room projector. Intranet structure for videoconferencing support includes a VTEL (VideoServer) gateway, gatekeeper and multiconferencing control system (MCS) which provide for management of three or more conferencing participants, any of which may be telephony (H.320) or Internet (H.323) based.

The University of Minnesota Internet Classroom

At the University of Minnesota the course is held in one of the University's UNITE (UNiversity Industry Television for Education) classrooms, equipped with cameras and microphones for broadcast and recording of all instructor and student interaction. State-of-the-art educational technology is supported in the room through overhead document cameras, videotape playback facilities, computer connections, and internet access. A number of local and regional industrial sites are equipped with audio and video hardware which allows them to tie into the UNITE system. Programming is broadcast live over an ITFS microwave channel, with talkback from off-campus sites to the on-campus classroom provided by a dedicated FM link or telephone lines integrated with the UNITE system. Students from IBM Rochester and Guidant Corporation (St. Paul, MN) are currently participating in this manner.

In recent years, UNITE has also been offering internet-based streaming video delivery of select courses. The streaming video program is designed to afford both on-campus and distance learners any time, any place delivery of courses. Class sessions are available for synchronous and asynchronous viewing over the internet using free RealNetworks software. Students viewing the live stream can phone into the classroom to ask questions and participate in the discussion. After class, by 10 P.M. one working day following the on-campus delivery, class sessions are available for students to view or review as needed.

Running in parallel with the UNITE broadcast, internet video conferencing is provided as a third means of distance participation. White Pine Software's CU-SeeMe is used to connect to partner institutions and participating individuals. Thus, two separate video signals are managed and broadcast from the University of Minnesota classroom. The high-quality UNITE television network allows students to view the lecture notes and other presentation materials in addition to the professor and the classroom participants. The internet broadcast, however, is limited to relatively low-resolution video images. To accomodate the presentation of course material, remote sites are provided with electronic copies of the lecture notes as well as the students' homework and case study solutions discussed in class. Thus, the video signal broadcast over the internet is mostly reserved for the current classroom speaker's "talking head." Conversly, when receiving lectures and other presentations from the remote sites, the classroom views a local copy of the lecture notes or other materials while listening to the internet-delivered audio.

Both during and between classes, much coordination is required to effectively communicate between the various participants. In class, in addition to the professor and the UNITE camera operator, a third person (teaching assistant) is required to serve as the "production assistant." While the local professor is lecturing, this person is available to coordinate between the professor and UNITE operator, pull up the course notes and other presentation materials on the computer, and communicate with remote sites using the telephone or CU-SeeMe's text-based chat utility. Outside of class, the course webiste serves as the focal point for getting information out to students: lecture notes, video segments of background lectures, supplementary readings, homework exercises and case studies, sample problems and solutions, and links to other electronics cooling-related websites. Daily two-way contact is maintained via an email distribution list. The URL for the course is: http://www.me.umn.edu/Courses/me5348.

The University of Maryland Internet Based Instruction Facilities

The University of Maryland site at College Park offers a computer classroom with one instructor's computer that serves as a console for H.323 video conferencing and thirty-five internet connected networked computers (Fig. 1).

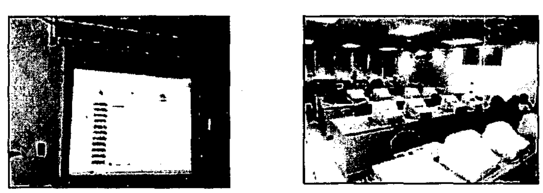

Figure 1: The University of Maryland Internet Classroom

A Polycom Videostation © camera coupled to an audio activated conferencing microphone is used to capture video and audio originating from the classroom and is input to a Videum© Capture card in the instructor's PC. Additional audio inputs are provided through a UHF wireless microphone, connected to the instructor's lapel, while omni-directional ceiling microphones serve to capture the student's audio signals which is also input to the Polycom camera audio input. An automatic audio mixer connected to a dual dynamic controller to act as a compression/limiter/expander gate is coupled to an octave equalizer and then on to a audio distribution amplifier and serves as a audio pre-processor before being routed into the camera audio input.

In addition to the Polycom camera, which is automated to activate zoom in on the audio source and can also be maneuvered as necessary through a hand-held remote control, a Canon© Visualizer is multiplexed into the camera station and can be selectively used as a video source for transmission of hard copy images or hand written notes by a switch at the hand held remote.

The instructor's computer serves as the video conferencing node using White Pine CuSeeme© software through H.323 networking and uses a H.261 video codec and T.120 data streams. The collaborative view panel of the CuSeeme window and the Instructor's PC monitor image is projected through a ceiling mounted Projector onto an electronic white-board. The electronic whiteboard serves as a laser sensitive mouse pad by using a laser pen.

All student computers across the sites use a Web portal to access all online content in the form of Microsoft©documents and Powerpoint© slides both during the progress of a lecture and asynchronously. At the University of Maryland, students use a course web site supported by Blackboard Inc. course management software, CourseInfo©. The URL for the course site is http://www.ajconline.umd.edu. Asynchronous video streaming of selected portions of course content is made available to course participants through use of a Realnetworks© server and Polycom Streaming Station©.

GROWING PAINS ASSOCIATED WITH THE NEW ENLARGED OFFERING

In offering the 2000 class, both the University of Maryland and Auburn University have migrated from conference room settings to larger computer equipped classrooms to accommodate the larger number of registered on-site students. The changes in the hardware to enable internet videoconferencing in these larger rooms have provided significant challenges in the first few classes. The limited bandwidth associated with the commodity internet pathway continues to be a significant challenge to real time video image transmission. A number of challenges are being faced for the first time, including different starting dates and durations of the academic terms at various educational institutions, and the variability in student backgrounds. Uniformity of grading, assignment of credit to non-academic participants, and teaching credit to the instructors also need to be addressed.

ONGOING EFFORTS ON MODULE STANDARDIZATION

The conversion of existing *asynchronous* course modules to a standardized format using the most pedagogically sound multimedia tools available is currently underway. A candidate technology suitable for this is *Sync-O-Matic 3000* software recently made available at Michigan State University which allows the combination of videotaped images with slides in a synchronized manner. The process is shown schematically in Figure 2. Other commercial programs for such purposes, e.g. Alive e-Show™ are also being assessed.

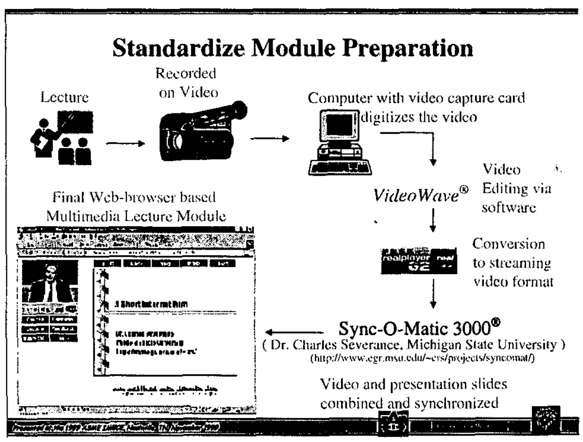

Figure 2. Creating standardized multimedia modules using *Sync-O-Matic* software

Some of the other key objectives of the current offering are to:

1. Continue to teach the course *synchronously* over the internet to multiple sites in a "live" format.
2. Draw upon resources and research backgrounds of participants to increase the number of available Case Studies.
3. Initiate a student evaluation study to track impact of the internet delivery as opposed to traditional methods. This learning outcomes assessment study at the undergraduate level will be fully consistent with the new ABET-2000 criteria. The University of Maryland, for example, has recently successfully participated in this certification effort and significant experience in the design of evaluation materials is available.
4. Create CD-ROM versions of course materials
5. Conduct regular on-line workshops to increase awareness of both course technical content and course development strategy.

ASSESSMENT OF EFFECTIVENESS THROUGH SURVEY AND BENCHMARKING

One of the important questions to be addressed with any new learning paradigm is the assessment of the effectiveness of the new approach, in comparison to the traditional, in-class lecture approach. Preliminary evidence exists, in support of the effectivess of asynchronous web-based materials for engineering instruction (Wallace and Mutooni (1997)). In this very interesting MIT study, the performance of a control group receiving classroom instruction only in product design was compared with another group receiving asynchronous web based instruction. The latter group was found to perform better than the former. A number of issues remain regarding the ability to generalize this finding, such as the small sample size (15 students in the web group and 21 in the classroom group), limited material (only one lecture in an entire course), and a single institution. Some of the conclusions of this study in the form of student feedback comments that bring out the advantages and limitations of the web approach approach are extremely useful. The web based instruction was liked for its ability to be used in a self paced manner (indeed the students went through the ninety minute lecture in an average of three sittings), anytime, anyplace. The multi-media features such as video clips were found to be very useful in explaining concepts. The students receiving web based instruction complained about having missed in-class discussions and were concerned about the time spent on learning the technology aspects of web learning compared to the material itself.

In our efforts we have addressed the above comments by combining the best features of synchronous learning (instructor summaries of learning materials, live case study presentations by design groups, and expert guest lectures) with asynchronous learning. To assess the effectiveness of this approach, several instruments exist. First, it is possible to design and carry out student surveys in a manner similar to Wallace and Mutooni (1997) by using a web based learning group and a control group. The design of the survey can be done based on the learning outcomes criteria that are part of the ABET 2000. The College of Engineering at the University of Maryland at College Park has recently gone through this review process and the substantial experience in the implementaion of this survey exists.

Another component of the evaluation process is benchmarking. Using this we can identify the best practices in the area of web based distance learning. The technical area associated with the current topic offers a natural opportunity for carrying out such benchmarking due to the multi-institution teaming. The characteristics of the web based learning programs at each of the three institutions can be compared to come up with a set of best practices that can serve as useful guidelines for other institutions.

CLOSURE

In summary, the current offering of the internet-delivered national course on thermal management is following the successful track record of its original presentation in Spring 1999. Several new features are being introduced and challenges are being addressed. The availability of inexpensive internet tools makes the current format extremely viable for a vast array of courses. The authors plan to use the success of this embryonic effort to launch a widely-available international course. It is also hoped that the dissemination of information on the methodologies used, and the journey up the learning curve that led to a successful implementation will be useful to others developing similar modular materials. It is hoped that this model can be used for any multi-disciplinary course, particularly those in emerging technologies.

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REFERENCES

Bar-Cohen, A., Bhavnani, S. H., Joshi, Y., and Geisler, K., 1999, "Teaching Thermal Design of Electronic Systems on the Internet: National Course Experience", Proceedings of the 2nd International Conference on Electronic Packaging Research and Education for the 21st Century, Atlanta, GA, March 17-19, 1999.

Bhavnani, S. H., Bar-Cohen, A., and Joshi, Y.,1999, "The Classroom of the Future: An Internet-Delivered National Course on Thermal Management of Electronics", 1999 ASME Curriculum Innovation Award winning paper, presented at the International Mechanical Engineering Congress and Exposition, Nashville, TN, November 1999.

Chute, A.G., Thomson, M.M., and Hancock, B.W, 1999, *The McGraw-Hill Handbook of Distance Learning*, McGraw-Hill, New York, New York.

Joshi, Y., Bar-Cohen, A., and Bhavnani, S. H., 1999, "Internet-Based Instruction for Thermal Design of Electronic Products-Making a Global Impact", Proceedings of the 49th Electronic Components and Technology Conference, San Diego, CA, June 1-4, 1999.

Wallace, D.R. and Mutooni, P., 1997, "A Comparative Evaluation of World Wide Web-Based and Classroom Teaching", *Journal of Engineering Education*, July 1997, pp. 211-219.

Reingold, J., Schneider, M., and Capell, K., 1999, "Learning to Lead", *Business Week*, October 18, 1999, pp. 76-94.

Epper, R.M., 1999, "Applying Benchmarking to Higher Education Some Lessons from Experience", *Change*, November/December 1999, pp. 24-29.