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Multimedia Engineering Courseware: Delivery and Assessment

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The ECSEL Coalition (CCNY, Howard, Maryland, MIT, Morgan State, Penn State, and Washington) and the Synthesis Coalition (Berkeley, Cal Poly SLO, Cornell, Hampton, Iowa State, Southern, Stanford, and Tuskegee) were the first funded in the National Science Foundation's Engineering Coalition Program. They began operation in October 1990. One of the areas that coalitions have been active in is the preparation, use, and assessment of multimedia engineering courseware. This paper focuses on the learning environments needed for delivery of this courseware and the evaluation of its efficacy.

DELIVERY

THE NATIONAL Engineering Education Delivery System (NEEDS) is comprised of a searchable database of catalogued courseware [1,2], a local school's courseware studio to create and revise courseware [3,4], and the local school's systems to deliver the courseware to the intended audience [5,6]. Various learning environments necessitate flexible delivery systems for courseware. The most-often-used learning environment for engineering education is the classroom or laboratory, but others would include an individual's (student or faculty) workstation, small study groups, and distance-education systems.

The engineering classrooms can be categorized into three groups based roughly on cost and capabilities [7]. At the high end are state-of-the-art, high-technology classrooms such as the one shown in Fig. 1. These rooms are capable of displaying any media on any platform desired, as shown in Fig. 2, are wired to the Internet for easy transfer of files, and often are capable of recording sessions and serving as distance-education origination sites. In these rooms a great deal of attention has been put to the learning environment—acoustics, lighting, and other ergonomic issues. The intermediately priced rooms will have permanently installed media equipment, although perhaps not all platforms and media will be served. They are typically larger classrooms for 'big' lecture audiences. The lowest-cost alternative, and the cost decreases continually, consists of a computer-on-a-cart rolled into a standard classroom [8]. A system can be purchased for under $10,000 which is capable of delivering high-quality multimedia images to a classroom which contains only a projection screen.

Figure 3 shows an example of a portable system as listed in Table 1. To this configuration one could add a VCR, videodisc player, or other equipment as needed and still remain under $10,000. This system would be capable of delivering the same multimedia materials as the million-dollar rooms, but without the conveniences of the environment provided by the expensive rooms. They would also not be able to transmit sessions to a remote distance education site. Interest in such classrooms exists at all universities and corporations [9]. In fact, an electronic newsletter run by Karen McBride at the University of Colorado is a monthly update on the state of information technology on college campuses, including high-technology classrooms.

In recent years the learning-environments group of the Synthesis Coalition has begun to focus more attention on the small-study-group approach to teaching as this promotes more active and collaborative learning. The University of California at Berkeley has shown success in such an environment for at-risk students [10]. While distance learning and the application of electronic technology is not new [11], the promise of high-speed networking to deliver multimedia courseware to remote sites interactively will have far-reaching effects on education in the next decade.

Within the Synthesis Coalition, a World Wide Web document was created [12,13], to document the experiences, both good and bad, of teaching in high-technology learning environments. It is called the 'Best Practices Document'. It currently contains information gathered only within this one coalition on classroom use, but the plan is to extend and update this document by including contributions from all educators on not only classroom delivery, but related topics such as

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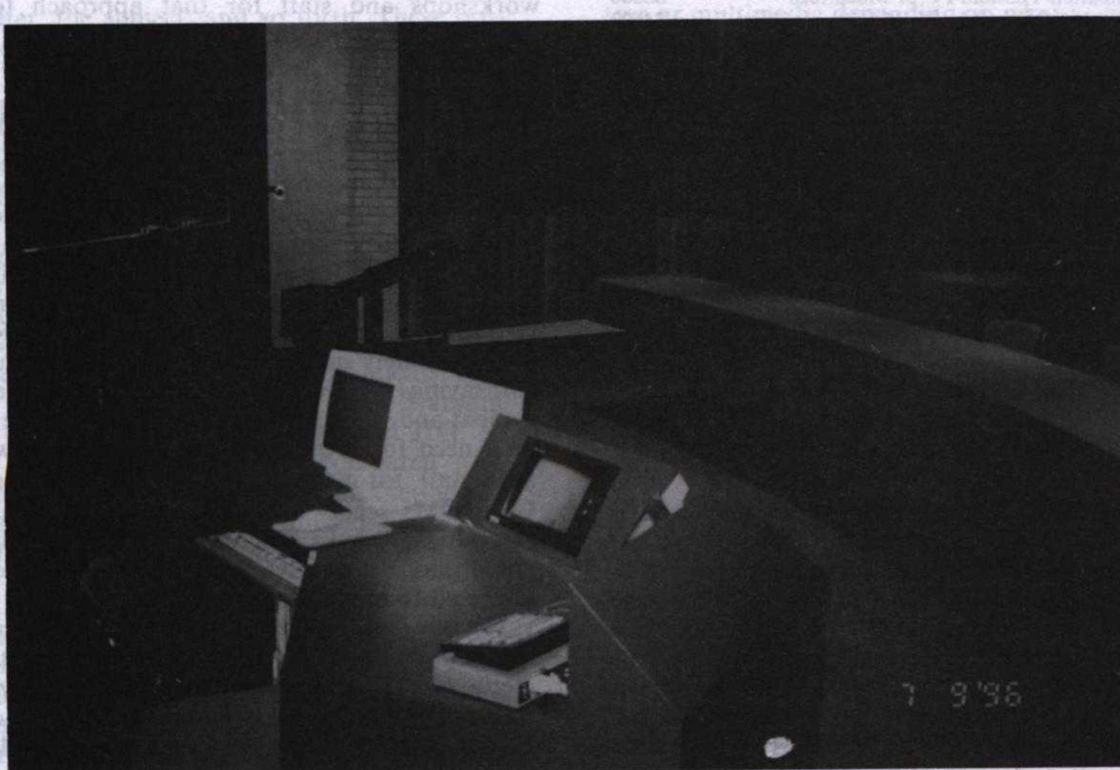

Fig. 1. One of ISU's high-tech classrooms.

Fig. 2. The control room for the high-tech classrooms.

Table 1. A low-cost multimedia delivery system

IBM-compatible Pentium PC or Macintosh	$2500
Active-matrix LDC panel with 16 million colors	$4500
High-intensity overhead projector (4000 lumens)	$ 500
Total	$7500

courseware development and assessment. This multimedia document resides on the world-wide web and can be reached at the following URL (uniform resource locator). http://needs.iastate.edu/-synth/main.html

ASSESSMENT: IS STUDENTS' USE OF MULTIMEDIA MORE EFFECTIVE THAN OF TEXT?

Parents and educators, excited or appalled at the hold that video games can have on young people, are trying to transfer this fascination to education. So-called 'multimedia' instruction has some elements of hands-on learning. Almost everyone is in favor of students being 'hands-on'. One of the strongest and earliest advocates of this mode was 'Doc' Edgerton of MIT. When a student came to his lab with a question he would give the student some tools and apparatus and say 'Make it and find out!' It was all the better, as far as 'Doc' was concerned, if the student had fun without realizing that s/he was learning.

We cannot, alas, use this method for mainline education. We cannot, at the present state of education funding, have enough laboratories and workshops and staff for that approach to be feasible. Therefore the vicarious exposure of students to labs and workshops through video and computer simulation has obvious attractions. The funding required for producing multimedia is not small, however. The effort required to put out a CD-ROM that would have the content of a medium-sized textbook on, say, machine-design is 10–20 times that of the effort to write and publish a new textbook (one author's estimate based on personal experience of producing multimedia). One can imagine that, if the CD-ROM were extremely successful, it could start producing cost savings if it were given to or acquired by every student and every teacher in a subject. There may be a need for fewer instructors and fewer workshop staff, for instance. The reproduction costs of CD-ROMs seems likely to be less than that of reproducing books. Therefore a major investment could lead to a positive benefit–cost ratio. It could also lead to more-effective instruction.

No one has yet proven this point: that multimedia instruction is more effective than traditional methods. There are some noteworthy developments, however. A short course of instruction in French in which the student seems to be wandering through a Paris neighborhood, going into shops and houses if s/he wishes and asking questions of the people s/he meets, has been produced by Gilberte Furstenberg at MIT. It seems highly effective and, now that the up-front costs have

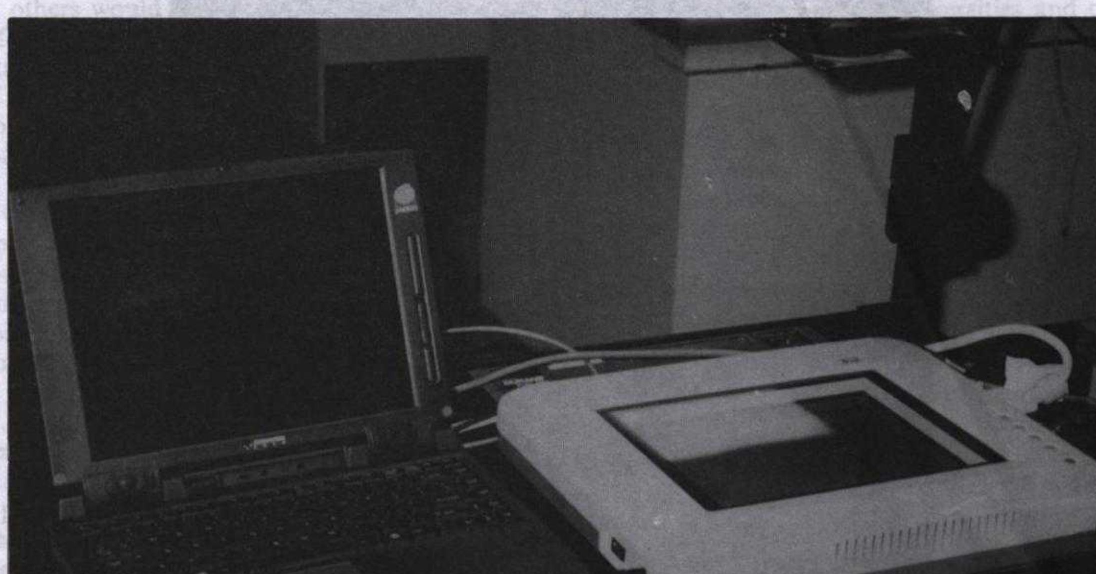

Fig. 3. A computer-on-a-cart.

been met, low in cost for self-study use. Another program, originally on videodisc, captures all the paintings in the National Gallery of Art; students may find background information on the process, the painter, the subject, and so forth. These programs seem intuitively better than text. Learning French by interacting with the virtual reality of French people in their streets and homes has to be better than learning verbs from a book.

Yet is it? It may be more fun, but is it faster, more effective, less costly? It turns out to be rather difficult to prove. One of the authors has been working with many others at MIT and beyond to produce an interactive multimedia program to give instruction to mechanical engineering design (EDICS: engineering-design instructional computer system). We decided to use the talents of a visiting doctoral student from the Harvard School of Education, David Crismond [14], to test the effectiveness of EDICS compared with instruction using text. This sounds on the face of it simple enough. The details turned out to be quite difficult. Here are some of the problem areas.

1. There is never an exactly equivalent text. Even if one bases a multimedia program on an existing text, one would (should?) incorporate moving video and sound on the multimedia program instead of the still photographs and written material in the text. There will be more details visible in the video than in the text, and more details written about in the text than in the multimedia program (large blocks of text are more tedious on a screen than in a book).
2. Testing these two treatments can therefore by biased. Questions on visual details will favor multimedia, while questions on material that is best conveyed in writing and tables will probably favor the text.
3. When one is testing material that involves searching, a bias will be found that depends on the quantity of material. We are all used to flicking through the pages of a book, allowing a kaleidoscope of images to pass in front of our eyes until we stop at something familiar. At the present stage of technology this is a much slower process on the computer screen. On the other hand, computer searching for a heading or phrase is extraordinarily fast, far faster than looking through a book's index.
4. As the amount of material to be searched increases, the advantages of text in searching for visual clues decreases. Imagine having to flick through 10 or 20 books looking for an epicyclic gear set. Moreover, only a very few sets of 10 or 20 books have a common index (a multivolume encyclopedia is an example). Therefore searching the many indexes of a set of texts becomes tedious. The computer part of the multimedia program would have a decisive advantage in being able to search all the material for topics with extraordinary speed and thoroughness.
5. One presumably could, therefore, set tests that, while being ostensibly fair, could favor either text or multimedia depending on what acquired knowledge is being tested, on how much material is being tested, and on whether the test is 'open book' or 'closed book'.

The ultimate test is whether an engineer educated principally on text will be objectively a better engineer than one educated with recourse to multimedia. The qualities that make a good engineer include being able to tackle a wide range of problems, both with and without reference to reference materials; using judgement when data are unavailable; using information from a very wide range of previous solutions; arriving at creative solutions when these produce a higher benefit–cost ratio; making no errors that result in harm; and so forth. Such a test is so complex that one is tempted to suggest an approach analogous to that used in medicine: epidemiology. Science cannot predict the effect of many medicines and environmental factors on humans. In epidemiology the frequency of occurrence of illness, disability, and death is correlated with diet, medication, lifestyle, and environmental factors to determine if cause-and-effect patterns evolve. The ultimate test of alternative instructional methods may be similar correlations.

We did, however, carry out tests of 40 students using the EDICS multimedia system and using just the textual material [15] in the most careful way we could, giving preference to text where possible. The results favored the multimedia instruction—rather narrowly overall, rather convincingly for the inexperienced students for whom EDICS was designed. As these results were obtained with a crude first-generation partly completed program, we believe that multimedia instruction in at least certain topics will be very effective.

CONCLUSIONS

We have briefly described some of the work on multimedia instruction being carried out in two of the engineering coalitions partly funded by the National Science Foundation. The Synthesis Coalition has emphasized delivery systems, and we have described a range of systems from entry-level, local, low-cost to sophisticated, networked, country-wide, high cost. The ECSEL coalition is perhaps further in the development of actual multimedia systems. We outlined some experience with one system, EDICS. We concluded that the development of high-quality multimedia is extremely expensive, but that the up-front costs may be justified by the higher effectiveness in instruction, as measured by a rigorous assessment applied to a necessarily somewhat crude, early example of multimedia, and by the eventual lower costs of distribution.

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