

# Creating Courseware for Engineering Education

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## Introduction

This paper will describe recent experiences at Iowa State University in establishing and using multimedia support capabilities to produce instructional modules for support of several classes. It will describe how these techniques have evolved over the past two years in support of an introductory course in digital logic design, and are now being applied to freshman year design courses.

### History of the SetFourth authoring studio.

The promise of computer-based technology, particularly the rapidly emerging multimedia segment, led to the 1990 establishment in the Iowa State University Engineering College of the **Studio for Exploiting Technology To Teach Technology (SET<sup>4</sup>, later SetFourth)**. SetFourth was established to pursue the following goals:

1. Develop multimedia tools to support a broad range of instructional efforts related to engineering education.
2. Reduce the learning curve for faculty in use of these tools.
3. Develop networked distribution and database access methods for the produced materials.
4. Develop networked linkages between studio users (authors and students), studio facilities, and instructional delivery facilities.

The philosophical principles governing operation of the studio are:

1. To stress cost-effectiveness through exploitation of available software and dependence on broadly-used and relatively low-cost delivery platforms.
2. To evolve the use of multimedia technique naturally by using simpler capabilities to immediately "rapid-prototype" instructional material, blending in more advanced features as technology and author/studio capabilities progress.
3. To encourage and support an appropriate level of faculty literacy with respect to multimedia, a minimum level consisting of fundamental computer-based drawing and text-entry skills suitable for visualization and prototype implementation of instructional modules.

Initial funding for SetFourth came in the form of a \$40,000 seed grant from the ISU Engineering College, which provided the following:

**Equipment** — At the time of SetFourth establishment, personal computers were perceived as offering the best combination of affordability and available software appropriate to studio goals. The

Apple Macintosh was chosen as the authoring vehicle, since it offered the most advanced, affordable, and easy-to-use multimedia support capabilities among the available choices. For its initial configuration, SetFourth was able to procure one Macintosh IIfx, three Macintosh SE, and three Macintosh Plus units, the latter intended to serve as test vehicles for student use of the proposed instructional material. Other significant equipment included a laser printer, a digitizing tablet, a CD-ROM player, a magnetic tape drive, and a file server coupled to a 150 Mbyte disk carried over from another project.

**Software** — Apple's Hypercard was initially envisioned as the primary software development and delivery vehicle. A number of the other "standard" multimedia support packages (Macromind Director, Studio1, etc.) were also evaluated. The biggest breakthrough in this area came rather accidentally in the form of a package deal for a set of equipment which incidentally included a license for Authorware Professional, which has subsequently become the software of choice, as described later.

**Staff** — SetFourth has been staffed exclusively with undergraduate computer engineering students, each employed as a 1/4 time assistant. The initial staff was three such students, and this number has grown to six.

### Initial Efforts

The initial target was to develop computer-based tutorial modules to serve as auxiliary support for regular courses. The first subject area treated was to be introductory logic design, and an Authorware "template" into which the tutorial elements could be embedded was written. Figure 1 shows the appearance of a typical module based on this template. It was designed to be displayed on a 9" Macintosh monochrome screen, and had reasonably good capability for student-interactive search and navigation through the material.

As module delivery began, the emphasis shifted toward production of modules containing problems and solutions, both from textbook-based homework and from previous quizzes and examinations. Figure 2 shows a screen with a typical problem/solution presentation, embedded within the same rather limited Authorware template of Figure 1.

### Growth

In late 1990 two significant events made it possible to dramatically expand the capabilities of the studio environment. The first was an NSF ILE grant to Professor Charles Wright, supporting establishment of an extensive laboratory of networked Macintoshes providing an appropriate delivery environment for the SetFourth products. This grant also supported procurement of significantly-expanded SetFourth capability, including two 650 Mbyte file servers, upgraded



workstations, additional software tools, and network bridges to link the laboratory to SetFourth, to faculty offices, and to the campus and beyond.

The second major event was the establishment of the NSF-sponsored Synthesis Coalition, membership consisting of eight major engineering schools including Iowa State University. Since the goals of SetFourth are consistent with those of the Coalition, SetFourth has been an active participant in Coalition activity, and has been significantly upgraded through Coalition support.

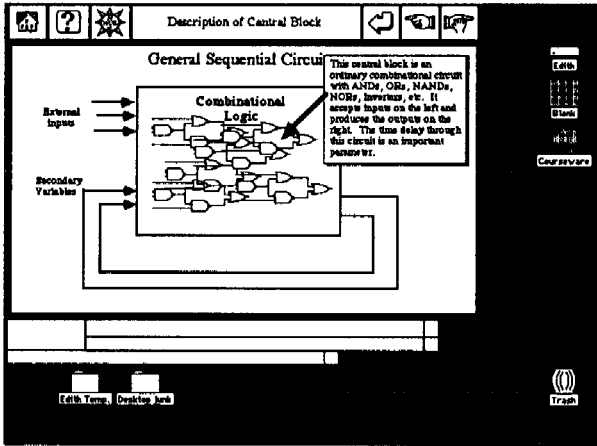


Figure 1. Tutorial Display

**Present Status**

At the present time, the SetFourth studio has five Macintosh II-class authoring stations and a variety of associated media production equipment for producing video, animation, sound, and assorted graphics elements for use in instructional modules. It manages two 650 Mbyte file servers, one for studio use, the other for general student use and for delivery of Authorware modules in three courses at the present time. It also manages the networking configuration of this complex through eight Cayman Systems GatorBox network bridges.

The student-accessible laboratory serviced by this system has a total of 54 stations (18 Macintosh SE30's and 36 large-screen color Macintoshes). A large complement of application software is locally resident on each system, with licensing restrictions managed through networked Key Server software which restricts usage to the appropriate maximum number in each individual case.

**Authorware characteristics**

The attractive features of Authorware Professional as a vehicle for production of educational materials are:

1. An excellent user (author) interface, providing a graphical icon-based structure for establishment of the logical structure of instructional modules, and an editing mode supporting creation of display elements within the student-oriented context, allowing the author to immediately see the results of his work and easily modify them to his purposes.
2. Separate authoring/delivery environments. One may develop modules using the relatively expensive authoring software and package them into deliverables which are legally and freely distributable within an educational context. At author option,

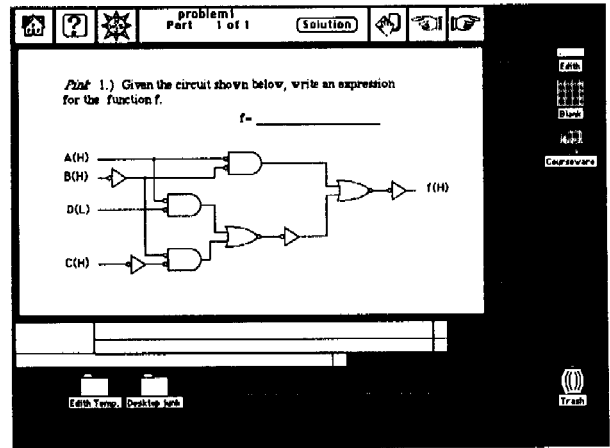


Figure 2(a) Problem Display

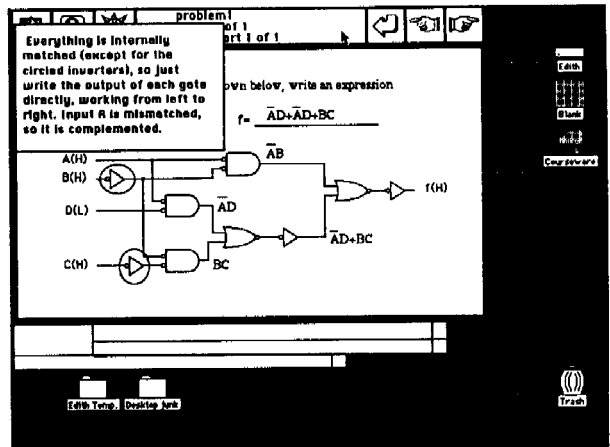


Figure 2(b) Solution Display

the runtime software may be embedded within the deliverable module, making such modules totally self-contained for transport and execution.

3. Convenient support for submodule transportability. For example, if a particular treatment has been created for a particular course or in support of a particular text, it may be easily extracted and saved as a separate entity in a scrapbook file for subsequent use in other modules.
4. Easy editing and updating capability. Error corrections or changes are easily accomplished by executing the software in author mode, observing the material to be edited, and entering corrections and changes directly on the screen.
5. Support of object-oriented (PICT) graphics. Such graphics, in contrast the bitmapped variety supported by Hypercard and many other packages, can be manipulated and transported with great flexibility. Graphics elements can be prepared in drawing or applications packages and easily imported into the Authorware environment.
6. A wide variety of multimedia support, including color, sound, video disk, animation, simple "movies", and various



combinations of all of these.

- Cross-platform support, including Macintosh and Microsoft Windows. Modules authored in the Macintosh environment can be transported into the Windows environment. Authorware recently announced an intention to support the Silicon Graphics workstation environment in the future.

The principal disadvantage of Authorware Professional is economic. In the industrial marketplace it is priced at \$8,000 per license. In the educational framework, it is discounted to \$995 per license. Site licenses are available, but would require very broad institutional usage to be cost-effective.

#### Current Status

The early focus on problem sets and solutions has been maintained. There are four semesters' worth of homework problems and examinations, all with worked solutions, in the student-accessible data base for CprE 280. Figure 3 shows a screen display of the current data base for this course.

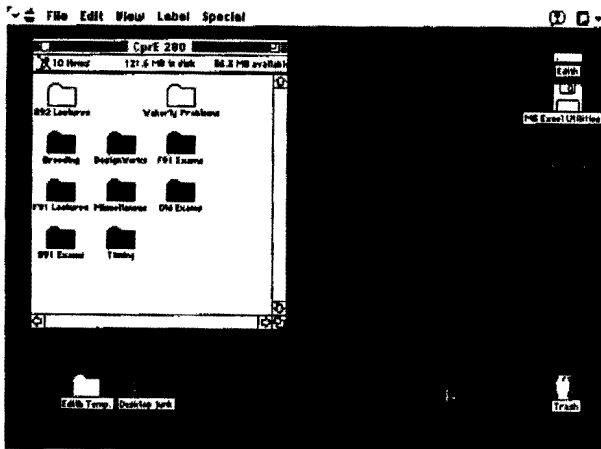


Figure 3. CprE 280 Database Display

The early intention to produce extensive tutorial material has taken the form of entire sets of lectures placed into the Authorware framework. These lectures comprise the in-class presentation via computer projection, and are additionally accessible on an individual basis through the laboratory framework. Hard-copy copies of the screen displays are available through a local copy center for those students who wish to reduce extensive note-taking in class.

We are changing textbooks this current semester and therefore testing the capability of the system for supporting re-use of material from one environment to another. Figure 4 shows two screen displays, one from a previous semester and dealing with a particular topic, the second from the current semester and showing how the older material was integrated and slightly modified to reflect new requirements.

Another Computer Engineering course, *CprE 580: Networking*, is currently using the SetFourth authoring facilities to produce a similar treatment this semester. This activity tests several aspects of the system. First, a new author, Professor Douglas Jacobson, is testing the use of the tools developed by the SetFourth staff, and is taking a rather ambitious route by making extensive use of Authorware-based animation tools to illustrate flow of information through networks.

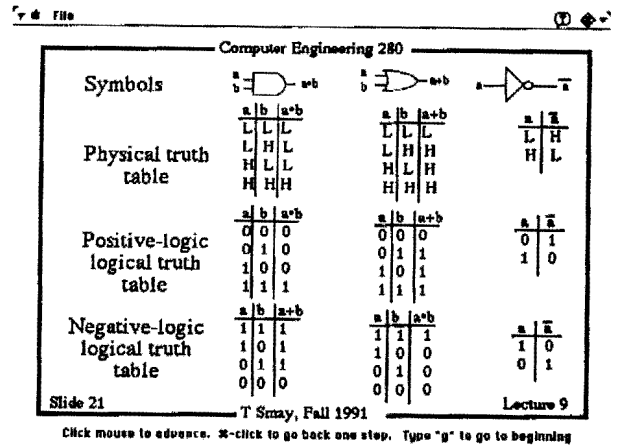


Figure 4(a). Original Tutorial Screen

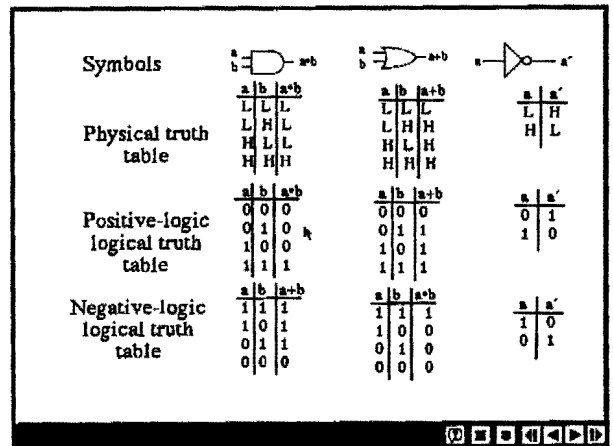


Figure 4(b). "Reused" Tutorial display

Second, he is delivering this material both on- and off-campus through National Technological University, and must therefore transport the material into the Windows environment to render the material transportable to a broader range of user environments. Figure 5 shows a screen from one of the Jacobson modules. Note the similarity of the interface to the one of Figure 4a, which used the same SetFourth module structure.

#### Student Evaluation

Near the end of Fall 1991, a survey was taken of student attitude toward usage of the various computer-based instructional support for **CprE 280, Introduction to Digital Technique**. The questionnaire asked to comment on the value of 16 items, six of which dealt with the mode of delivery of the material, and ten of which dealt with a variety of supporting elements. The items are listed below, the number in parentheses in each case indicating the percentage of those responding (95 out of a class of 200) who made significant use of the item.

##### Mode of Delivery

- Overhead-transparency lectures in class (100%)
- Computer-projected lectures in class (100%)
- Computer-accessible lectures in lab before class (66%)



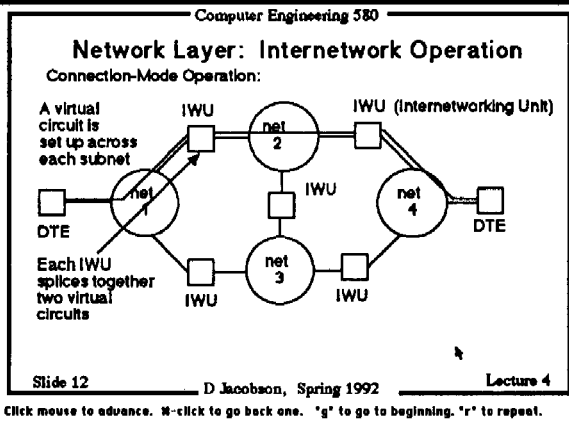


Figure 5. Screen from Networking Lecture

4. Computer-accessible lectures in lab after class (72%)
5. Computer-accessible lectures instead of class attendance (43%)
6. Hard-copy lecture slides from copy center (78%)

#### Supporting Material

7. Solutions to Breeding problems on computer (80%)
8. Breeding solutions manuals in library (56%)
9. Solutions to old examinations on computer (81%)
10. Tutorials on computer (63%)
11. Help Sessions by Smay (52%)
12. Help from Teaching Assistants (37%)
13. DesignWorks simulations in class (96%)
14. DesignWorks simulations on your own in the lab (39%)
15. Use of modules on other campus computers (32%)
16. Use of modules on your own computer (23%)

For each of the items used, the students were asked to evaluate its effectiveness according to the following scale:

- 0 - Totally useless or ineffective
- 1 - Of limited usefulness or effectiveness, not very important
- 2 - Of some benefit, worthwhile
- 3 - Significantly useful or effective, important
- 4 - Critically useful or effective, needed it
- 5 - Absolutely necessary, couldn't do without it.

The survey produced the following results:

1. Both "hard-copy lecture slides" and "old exams on computer" were considered critically important (rating 4 or above).
2. "Computer-accessible lectures after class", "problem solutions on computer", "tutorials on computer", "instructor help sessions", and "use on your own computer" were rated between 3.5 and 4.
3. All the other items, except for "DesignWorks in class" (rating 2.8) were rated between 3.0 and 3.5.
4. When the effectiveness ratings were multiplied by percentage of class usage to give a figure of merit for overall effectiveness, the top item was "old exams on computer", followed by "hard-copy lecture slides" and "problem solutions on computer". "Overhead transparencies" and "computer-projected lectures" also showed up with high ratings, but these were considered a bit artificial since the captive-audience

#### Cross Platform Issues

In an Engineering College the size of that at Iowa State University, the need exists to be able to deliver multimedia lessons on a variety of platforms. Since the EE/CprE Department had extensive experience with the Macintosh version of Authorware, and since Authorware recently released an MS-DOS version, we decided to attempt some cross platform experiments in the delivery of Authorware lessons, with resources provided by the NSF-funded Synthesis Coalition. The coalition also was at this time conducting experiments in use of high-technology classrooms which have proved to be an ideal setting for delivering multimedia lessons. Iowa State has constructed two such classrooms which allow the instructor, at the touch of a button, to switch images among computer output, live camera demonstrations, videodisk, videotape, and slides.

An introductory required engineering course, **Engineering Problem Solving with FORTRAN Programming**, was selected to support the first experiment with the MS-DOS version of Authorware as well as the first course taught in the new high-tech classrooms. This is a freshman-year course which sees an enrollment of about 500 students per semester. This course is served by three computer labs outfitted with 64 networked MS-DOS computers. The Authorware lessons are accessible over these networks for the students as well as for the instructors' use in the high-tech classrooms. Authorware lessons are being created for each class period during the semester. Instructors typically teach from these lessons while interspersing other material shown via the video camera or other media support features in the lecture rooms. Open lab hours are maintained so that students can view the lessons.

Each lesson contains a "lecture only" path and an interactive, tutorial path. This allows each student to review the lecture material and perform "drill and practice" exercises at his/her own pace to reinforce the material. The software allows the tabulation of student results while using these lessons. Items such as time spent on the lessons and correct responses to questions for each student can be recorded. Printed copies of the lessons are also made available so that students have a concise set of course notes from which to work.

Since Iowa State received one of the first MS-DOS versions of Authorware (in fact, a "pre-release"), some conversion problems were originally encountered when translating lessons created on MacIntoshes. Colors, fonts and screen position coordinates were particularly troublesome. Within a few months a new version of the MS-DOS software removed many of these difficulties. As of this writing, we are still encountering some translational problems while using some of the more complex branching capabilities of Authorware. Generally speaking, however, we are very encouraged by the results obtained at this early stage of development.

#### Conclusions and Observations

1. The original goals of the SetFourth authoring studio have been met. An excellent set of templates and authoring tools have been developed and widely used by a variety of authors. These tools continue to be refined and improved by a capable staff of undergraduate assistants, working closely with the instructors involved to support individualized pedagogical methods. Once having experienced a brief period of indoctrination in use of these tools, instructors are able to produce high-quality presentation materials with modest effort.

2. The material has proven capable of convenient networked transport, both within and beyond the Iowa State campus. Convenient transport of "raw material" between authoring instructors and support staff as



well as finished instructional modules to a variety of student-accessible platforms is well-supported.

3. Authorware Professional has proven to provide an excellent authoring environment, with a number of important features and advantages, including an intuitive editing interface, support for module reusability, separation of authoring and delivery environments, and cross-platform (Macintosh and Windows 3.0) translation and support capability.

4. The cross-platform support experiments are very promising, and promise to greatly expand the "audience" for the material. Jacobson's dual-platform experience is well-established and the freshman engineering experiment in progress seems likely to be highly successful.

5. The surface has barely been scratched. We hope to achieve a much greater degree of user-controlled interactivity and to integrate a more extensive suite of media into near-future material.

### Acknowledgments

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Lawrence J. Genalo obtained the B.A. degree from Hofstra University in 1971, and the M.S. and Ph.D. degrees from Iowa State University in 1974 and 1977, respectively. His Ph.D. was in Applied Mathematics with an emphasis in Systems Engineering. He has been at Iowa State since 1971, and has been an Associate Professor since 1981. He has served ASEE as Program and Division Chairs for Freshman Programs and DELOS. His current research interests are in bringing high-technology to the classroom through his involvement in the NSF funded Synthesis Coalition.

