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Engineering educators have long recognized that some of the technology created by engineering can be used to educate future generations of engineers. Television is a good example. There are several basic ways television can be used as an educational tool. First, it can be used to transmit information to many different locations simultaneously. Second, it can be used to transmit information instantaneously to or from remote locations. Third, it can be adapted to display instantaneously the output from both digital and analog computers. The words "simultaneously" and "instantaneously" are key words because otherwise conventional film could do the same thing. Even in applications where "simultaneously" and "instantaneously" are not critical adverbs, the video tape medium has some advantages over film. Specifically it can be erased and reused continuously and it can be replayed immediately after recording without intermediate processing. However, we really shouldn't think in terms of video tape versus film but rather that they are two media that have both similar and dissimilar characteristics which make it possible to use them in a complementary mode as well as in a competitive mode.

The purpose of this paper is to discuss an application of video tape where neither the simultaneous nor instantaneous nature of the medium is important. In the Electrical Engineering Department at Iowa State University, we are experimenting with the use of video tape as a tutoring medium. We are recording 20- to 30-minute lectures on video cassettes and then making the cassettes available to the student at the University library. The library has outfitted a room known as the Media Learning Center where the student can view the tapes in the privacy of booth-like areas.

The video cassette system has several features which make it very attractive to use as a tutoring medium. First, the system is extremely simple to use. All the student has to do is slip the cassette into the video tape player and press the proper control button. He does not have to learn how to thread a machine nor does he have to worry about having the tape come off the reel. Second, the video cassettes are easily stored and handled. In fact, the cassette container has about the same size, shape and appearance as a conventional textbook. Third, the video lecture can be dubbed directly onto the cassette at the same time a master tape is being made. Fourth, the cassette system has proven to be very reliable. The student can expect that when he wants to view a video lecture the equipment will be working.

The decision to experiment with video tape cassettes as a technique for tutoring students forced us to make three additional decisions.

First, we had to decide on a general subject area. We chose introductory circuit analysis. We felt this was a logical choice for two reasons. The course is taken by EE sophomores, which is the largest group of undergraduate students in our department. The other reason is that this course is the first course the student takes from the EE Department. Consequently, he has not yet developed alternate sources of information and therefore he is in more need of formal tutoring than he is in later courses.

Second, we had to select specific topics from within the general subject area. This was not a difficult problem because experienced staff members could easily flag the topics that were most troublesome for beginning students. We also selected topics that we knew upperclassmen had a frequent need to review.

Third, we had to decide on the format for the video lectures. Basically we wanted both a format and a production technique that were simple enough so that it would not require a professional camera crew, multiple cameras, special lighting, studio rehearsals, etc. These facilities and talents are available to us at ISU through the superb facilities of the University's television station WOI-TV. However, we wanted to develop a technique which could be used at locations where this type of equipment was not available. With the help of James Varnum, a producer at WOI-TV, we have developed a style of presentation which minimizes the requirements of the studio facilities. The production of the tutoring tapes is described in the following paragraphs.

A tutoring lecture is presented on a 17-by-11-inch quadrille pad which has a grid of four squares to the inch. The pad is securely fastened on a slanted lectern with the camera looking over the right (left) shoulder of the person giving the lecture. The lecturer is seated in a comfortable writing position at the slanted lectern. The camera stays in one position and is always focused on a 10-by-7.5-inch (40 x 30 squares) rectangle which is centered on each 17-by-11-inch sheet. The quadrille pads are left intact, so as the individual sheets are turned in the course of developing the lecture the next page is properly positioned in front of the camera. This method of preparing the tutoring tapes minimizes the actual time spent in the studio recording the lecture and at the same time it reduces the studio manpower and equipment needs. In exchange for these desirable production attributes the lecturer must spend more time and effort preparing the tutoring lecture. We have found that there are five factors which enter into the preparation of a tutoring lecture.

1. Predrawn material. To make good use of on-camera time it is essential to incorporate prepared material into the lecture. For example, having a circuit diagram or graph predrawn frees the lecturer to concentrate on discussing the significance of the circuit or the graph rather than the mechanics of drawing it.

2. Space control. The use of the quadrille pad forces the lecturer to develop his subject matter on a frame-by-frame basis. The use of predrawn material leads to partially filled frames. These frames are completed on-camera with material which must pedagogically support the predrawn material. It is important, therefore, to design the frames so that there is adequate space for the material that is presented "live."

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3. Visual quality control. The visual quality of the material presented on a tutoring tape must be excellent. To ensure that equations and lettering are highly legible to the viewer, it is necessary that the height of letters, numbers and symbols be at least one-tenth the height of the frame and their width one-twentieth the width of the frame. Subscripts and exponents are drawn approximately two-thirds size. In terms of the quadrille pads we have chosen to use (four squares/inch) and a frame size of 40 by 30 squares these ratios translate as follows: letters, numbers and symbols are three squares high and two squares wide; subscripts and exponents are two squares high and one and one-half squares wide. All lettering is done with watercolor brush tip pens which produce a line width of approximately ⅛″. It is important to use the watercolor-type pen because the permanent ink model will bleed through the paper and mar the following frames.

A second aspect of controlling the visual quality concerns the material that is presented "live." It is essential that this material be visually consistent with the predrawn material, and at the same time it must fit into the preassigned allotted space. We find lightly drawn pencil guidelines (which are invisible to the viewer) can be used to ensure uniform lettering, adequate spacing between symbols and horizontal equations which fit within the boundaries of the frame. These pencilled-in guidelines also minimize writing errors. This is desirable since it is not possible to erase material. Errors can be crossed out but the space cannot be recovered; hence errors jeopardize the amount of information that can be placed on a frame.

4. Timing. Video cassettes come in 10-minute increments. Therefore a preliminary timing run will give the lecturer a feel for what length of tape he should plan to use. For example, if a timing run indicates approximately 24 minutes, the lecturer can decide either to cut back the material so that a 20-minute tape can be used or to expand the discussion to fill a 30-minute tape. We have not, at this stage of the experiment, tried to match the presentation exactly to the length of the tapes. Most of our lectures run between 25 and 30 minutes and all have been recorded on 30-minute reels.

5. Special effects. In the course of developing a series of tutoring tapes, we have found several ways to enhance the presentation. We have used fold-ups to add an equation to an already filled frame. The fold-up allows easy reference to be made to the material already on the frame without the need to switch back and forth between frames. Slide-outs have been used to uncover predrawn material which comes at the bottom of a frame. This allows us to have the predrawn material under cover until it is needed in the discussion. Thus the predrawn material does not divert the viewer's attention from the material being presented "live" at the top of the frame. Slide-outs have also been used to shift graphs along a stationary time axis. In the tutoring tape dealing with power calculations, we constructed a very simple phasor diagram that could be manually rotated on camera. The special effects are used only when they enhance the presentation. They are not used to "decorate" a discussion.

Our experience with developing tutoring tapes has made it clear that there are more constraints involved in the preparation of a video tape tutoring lecture than in the preparation of a classroom lecture. It is important to recognize that material that the student can view only a frame at a time cannot be presented as casually as material that a student can continuously monitor as it unfolds on an 18-foot chalkboard. On a video tape material must be presented in a clear, logical, coherent fashion. A student can tolerate a somewhat disorganized "live" presentation because he can often get things clarified by asking appropriate questions. This option is not available on the tutoring tapes, and if the material is disorganized or illegible the student will choose not to use the tapes. These different requirements and characteristics of the video lecture as compared to the classroom lecture highlight the important point that tutoring tapes are not intended to compete with the classroom but to assist the classroom instruction. The tutoring lecture is also not a substitute for a textbook. The whole point of a tutoring tape is to help a student gain understanding of an important concept which he personally finds difficult to grasp. The tutoring tape can also be used to give the student an overview of a concept and stress its importance so that he will be motivated to pursue it in greater depth from conventional sources. We feel the video cassette system has a great deal of potential in engineering education. Tutoring tapes might also be integrated into a course where self-paced or individualized instruction is attractive.

An economic analysis or justification for developing a series of video cassette lectures is difficult to make. The cost of producing a lecture could be carefully documented, but we have not set up a detailed accounting system during this experimental phase. My guess is that the initial cost of producing a tape is approximately $100 per minute. However at this stage of the experiment the potential cost/student is unknown. We feel the topics will be of importance for at least five years, and perhaps longer. How many students will make use of the tapes in the long run is unknown. We have had the video cassette system in operation since September 1973, and over 100 students voluntarily used the tapes during the first year.

Overall we feel the experiment has been successful. We shall continue to monitor student use of the tapes, and if this use continues to grow we shall continue to produce tapes.