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The Production of Video Material for Integration into Courses*

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Video technology has diffused rapidly throughout the community in recent years. This paper outlines the processes involved in the production of a professional standard series of videos on engineering design. It examines the issues involved in integrating video material into teaching programmes. Emerging issues in the use of video including the impact of copyright regulations in respect of off-air recording are also reviewed. The paper draws upon experiences at both the University of Queensland and the University of Adelaide.

INTRODUCTION

ENGINEERING education is under increasing pressure to be more effective in its use of the limited resources available in most universities. Class sizes are growing and traditional teaching techniques can no longer be sustained. The revolution in computer technology during the 1980s, and in particular the development of powerful and relatively cheap personal computers, has been grasped by engineering educators as a means of delivering and supporting the engineering education experience. Nevertheless this technology *per se* does not represent a solution to a perceived problem. Computers are really only effective when integrated into a well-defined educational framework [1]. The rapid evolution and diffusion of video technology is directly analogous to the development of the PC. It too can be used as a powerful aid in presenting courses.

The use of video in engineering education has grown progressively over the past decade. This growth reflects dramatic changes in video technology over the period. In the late 1970s, video technology was restricted to the $\frac{3}{4}$-in. U-Matic format. It was expensive to make programmes and expensive to provide facilities to show video material. The technology was remote. In the 1990s, simple to use and relatively inexpensive home video technology, cameras and VCRs are widely used in the community. The change could not be more dramatic. Video technology has had a major impact upon contemporary society. Even more than television *per se* it has established norms for the style, form, presentation and accessibility of information. It is the vehicle for much of youth culture. It has opened up the world of asynchronous communication to the individual, i.e. the ability to present events out of sequence with their temporal origins.

This paper addresses this changing environment through a case study on the planning and production of a series of videos on engineering design for use in undergraduate education. This is complemented by a review of the integration of this and other video material into engineering courses. The paper concludes with a discussion of the emerging issues involved in the use of video within engineering education.

ENGINEERING DESIGN VIDEO SERIES: A CASE STUDY IN VIDEO PRODUCTION

A series of four video programmes, the Engineering Design Video Series (EDVS,) was produced at the University of Adelaide. The aim was to capture the very process of engineering design in a form that would be accessible to students. The EDVS was made as a collaborative effort involving the author, as the writer and executive producer of the series, and the Advisory Centre for University Education (ACUE). The series was produced as part of a broader effort to develop the design stream at the university.

Aims

The primary motivation behind the project was to convey the true nature of engineering design in a way that was not possible through conventional sources. Engineering design is a social activity [2], a journey of discovery [3]. Textbooks do not adequately convey this reality, and students have difficulty in accessing this social dimension. It was felt that video could convey to students something of the flavour of engineering design through the presentation on video of engineering design in the words of practicing engineers. The case study approach of providing a realistic introduction for

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students to engineering design is well established, though not with video as the primary medium.

The prospective audience for the EDVS was identified as being both first-year engineering students and students in their final years of high school making career decisions. In addition, it was hoped that the series would find a place in the first year of courses in related disciplines, including architecture and industrial design. Its role here would be to develop an awareness of the nature of engineering design among these students. A better understanding needs to be fostered between engineers and other design professionals.

Content

Each of the four programmes had a theme. These are outlined in Fig. 1. Videos 1 and 2 feature contributions from six engineers practicing in the Adelaide area. The design case studies included the development of a sheep-shearing robot, the design of a wheelchair restraint system for disabled children and the use of CAD in the design of office products.

The third video focuses upon a single project: the design and construction of the Adelaide Formula One circuit. This programme provides a personal perspective of the engineering behind this very public project. It encapsulates two of the key aims of the series: to have an Australian content and to have obvious appeal to young people. The final programme in the series was a joint effort with the Women in Engineering Group in Adelaide. It features a group of recent engineering graduates drawn from both the private and public sectors. In all the programmes the various facets of engineering design are presented as the direct observations and comments of the participating engineers. A series of short voice-overs, scripted by the author and spoken by a professional broadcaster, introduce the themes in the programme and link the segments.

Preparation

The EDVS concept and the themes for the individual programmes were discussed with staff from the ACUE prior to seeking funding. These initial ideas were refined to the point where a budget and a timetable for production were decided. Once the funding was obtained the basic scripts were worked up. The themes to be developed in each programme were decided by the author. From these a list of questions was developed as a joint activity between the author and the video director from the ACUE. The questions

ENGINEERING DESIGN VIDEO SERIES

This series of four video programs reveals the human face of engineering. It features engineering designers, including several women, working on a variety of projects ranging from sheep shearing robots through to water supply systems. The Series is aimed primarily at high school and tertiary students who are considering their future careers. Nevertheless the programs will appeal to a much wider audience, giving an insight into the creative challenge and existential pleasures of engineering design.

1 This Urge to Design outlines the typical stages in any design project, starting with the client's requirements. From here the iterative process of generating design concepts, developing a detailed design suitable for manufacture and ultimately seeing that the client is happy with the final product or service.

2 Beyond the Drawing Board explores the role of design graphics in communicating ideas from the design engineer to the other members of the team. The methods employed span from simple freehand sketching through to the most sophisticated computer-aided design techniques.

3 Streets Ahead focuses on the planning, design and construction of the award winning Adelaide Grand Prix circuit. It follows the ups and downs that occurred in the months, weeks and days leading up to the 1986 Grand Prix, viewed through the eyes of the engineer responsible for the project.

4 Shaping the Future presents engineering design as a career. It highlights the work experiences of engineers, their reasons for choosing engineering and the style of the courses undertaken at University or College. This program was produced in collaboration with the Women in Engineering group.

Fig. 1. Contents of Engineering Design Video Series.

were designed to elucidate comments and observations, from the designers participating in the video, that would develop the themes in each programme.

The participants were chosen from among the professional contacts of the author. An essential first step in making each programme was a visit to the work-place of each participant to (1) discuss the topics to be canvassed on the programme and (2) to assess the availability of suitable 'visual' material 'on site' or from archive footage. This pre-planning process took at least two days per programme. It was distributed over several weeks.

Methods

The production team from the ACUE consisted of a director, a cameraman and a sound recorder. For the first two programmes a professional interviewer was also employed. The author did the interviewing in the third and fourth programmes. Each filming session lasted at least half a day, usually a whole day. A total of 4–5 days of filming was necessary for each programme. This took place over several weeks, to fit in with the mutual availability of the participants, the author and the ACUE team. This involved considerable coordination on the part of the producer.

The post-production phase, in which the video material is edited into the final form, took between 3 and five days per programme. The first stage involved a review of the full transcripts of the interviews to decide which statements would be included in the final programme. This was done by the author. The voice-over introduction and links were also written to link the words of the participants. The decision as to what was included and what was excluded was controlled not only by the content but also by the fluency and clarity of speech delivery of the participants

The next stage was the physical editing to produce the master tape. First, the voice track including the voice-overs and musical links was assembled. Once the audio sequence was complete, the basic structure of the programme was fixed and changes could not be made easily. The visuals on this basic tape consisted solely of the 'talking heads' of the participants. Next the 'cut-aways' and other images necessary to complete the programme were copied onto the master tape in the appropriate places, over the talking heads. The final selection of visuals often took a considerable time. For each 16–20 min programme there were many hours of taped interviews and cut-away shots distributed over up to 20 tapes. The editing process was a collaborative effort by the director, a video technician and the author.

The final creative act was the design of the jacket covers for the tapes boxes and complementary brochures for the series. This was done by a freelance graphic artist from a brief given by the author. The video series had a formal, public launch. These were essential elements in promoting the series.

Funding

The total budget for the EDVS was in excess of A$14,000. Advance funding came from two sources; the Design Arts Board of the Design Council and the University of Adelaide Foundation. The remainder of the monies was raised by the sale of programmes to tertiary institutions throughout Australia. This budget was miniscule by industry standards, but large for a university video project. The budget did not include the cost of some of the ACUE staff or the time of the author. It did, however, include the cost of specialist post-production facilities in a commercial studio. In addition, a royalty fee had to be paid to FISA for the rights to include about 20 s of footage of the Grand Prix in programme 3.

INTEGRATING VIDEO INTO TEACHING PROGRAMMES

Course structure

Programmes from the EDVS have been used by the author in first-year graphics courses at both the University of Adelaide and the University of Queensland. The programme run times (16–20 min) were considered to be about the maximum duration for which the attention of students could be held. This also enables each programme to be used as supporting material in a traditional lecture.

A well-scripted video programme is self-contained. The images and arguments are fixed; they cannot be modified to suit a particular audience, or updated, as can a set of notes and accompanying OHPs and 35 mm slides. However, the emphasis of a video can be altered by focusing the audience prior to screening and by reinforcing a set of key points through discussion and summary after screening.

In later year courses within the Manufacturing and Materials schedule at the University of Queensland, we have incorporated other purpose-made videos, in particular Open University programmes plus some promotional videos made by companies. Often only a short segment—sufficient to support the lecture material—of a programme is shown. This portion can be slotted into the appropriate part of the lecture, and breaks up the monotony of the traditional lecture. In addition, some broadcast programmes have proven useful. One example was a 50 min national current affairs program in which a specialist, invited audience 'debated' the quality of Australian designed and manufactured products. This programme complemented lecture material and segments of it were used as a catalyst for a class discussion of the issues raised.

Relevance

Relevance is often closely associated with both the origin and the content of the programme. Balding, middle-aged executives extolling the vir-

tues of a highly specialized piece of technology in a foreign accent often generate scepticism and distance the audience from the underlying message. The material is perceived as being only applicable to overseas industry. In contrast, a relatively young graduate showing off the results of a recent project in local industry has much more immediacy and consequential impact. One such example used in the Engineering Design Video Series is design and development of a robot for shearing sheep.

The age of the programme seems to be another determinant of relevance. This is closely linked to the subject matter. For instance, a 5 year old programme involving computers is perceived as being out of date. Popular science and technology programmes broadcast on TV have a conditioning effect on the student audience. Videos can date very quickly.

Facilities

To achieve this integrated use of video requires appropriate playback facilities. The EDVS is aimed at first-year courses. This implies large numbers of students. Lecture theatres that incorporate a large-screen video projection facility are essential. The earlier technique of multiple monitors hung around the room is not satisfactory. Unfortunately, at the University of Adelaide in the mid-1980s the only lecture theatre with a projection facility could only hold half the class at one time. The viewings had to be held in succession. The University of Queensland has a central facility for running video projection facilities in all of the large lecture theatres on campus. The lecturer has full control of the tape. This makes it possible to slot material wherever required into the lecture. In addition, the students can screen the programmes individually or in small groups in the audio-visual library at a time that suits them.

Asynchronous communication

One of the most powerful features of video is its ability to distort time—to decouple events temporally. The domestic VCR has enabled people to decouple their viewing habits from the broadcast schedule. Programmes can be watched at a time that suits the viewer. This has significant implications for education.

The traditional series of scheduled lectures in a semester programme rests on the assumption, usually implicit, that at the prescribed time each week both the lecturer and the student audience will be personally, socially and intellectually ready for the particular lecture experience. This is clearly impossible to achieve. At any one lecture only a fraction of the students will be tuned into the material being presented. The time at which an individual student is ready to be stimulated or to receive new concepts or information is more a function of the student and their personal preparation than of an arbitrary lecture timetable. This mismatch between the presentation of a lecture and the state of readiness of the student is all the more important in engineering curricula in which many of the courses, especially in the early years, are compulsory and involve large class sizes.

Asynchronous access to material, including lecture presentations, via video libraries and a short-term, video-hire system, represents one of the most pervasive uses of video in courses. It is reasonable to assume that all students in a society such as Australia have access to a VCR for video playback; VCRs are more widely diffused than PCs. The video-augmented learning process is therefore in the hands of the individual student.

DISCUSSION

Too often we are slow to embrace new technologies in engineering education. The traditional 'chalk and talk' remains the dominant 'teaching' modality in many engineering departments. It is safe and easy. However, at this time of increasing student numbers and decreasing resources, the need to review critically our lecturing methods is all the more urgent. In this context, video can be used to good effect. Before rushing into the production and the use of video material, however, a number of critical issues must be addressed.

Production issues

Video is a creative medium. Programme ideas must grow within the domain of the medium. It is not possible simply to dictate to the medium. Making a video programme is a journey of discovery [3]. The final form of a programme may be quite different to that envisaged at the outset by the academic who conceived it.

Students are a sophisticated audience with a high, and rising, expectation in production values and standards and in programme quality. To meet these expectations, a relationship of mutual respect and trust must grow between the academic with the initial programme concept or idea and the video-maker who is to interpret this idea. A synergy must develop. Knowing what 'works' on screen is an essential ingredient, and judging this is a difficult task for someone not experienced in video or film-making techniques. What catches your eye as being interesting at an industrial site and what can be captured and conveyed on video are often quite different. Discovery can be a painful process.

Entry costs

Funding is an issue. The seed for the EDVS emerged from a workshop on university teaching methods given by the ACUE. The cost structure as it then existed did not discourage experimentation with video. However, the framework for the budgets of the EDVS changed during the course of the 2 years of production due to the pressure for all groups within the university to adopt the 'user-pays' principle. This increases the starting cost for someone wishing to experiment with video and thereby discourages exploration of the medium.

The rising cost of prerecorded and 'off-air' recorded programmes is also discouraging the wider adoption of video in engineering education.

Off-air recording

Broadcast programmes recorded off-air have been a potential source of topical, up-to-date video material. For a number of years there has been concern over the copyright issues involved in off-air recording of radio and TV programmes for subsequent use by educational institutions. In Australia, the position has recently been clarified. In May 1990, an agreement was reached between the Australian Vice-Chancellors' Committee and the Audio-Visual Copyright Society on a mechanism for protecting the rights of both educational institutions and copyright owners [5]. It involves record keeping and the payment of a fee by the institutions. The fees for TV programmes are grouped under three classifications. The current fee rates per minute are: Category A, A$4.50; Category B, A$2.50; and Category C, A$0.75. The agreement runs for 4 years and applied from 1 January 1990.

Category A programmes are those principally intended for educational purposes or having a significant potential market for sale as educational programmes. Category C programmes are classified as being news, current affairs, serials, series, light entertainment, sports and advertisements. Category B are those programmes not falling into category A or C. To date, no category A programmes have been notified to the ACDP/AVCC. Therefore there are effectively only two categories, B and C. Most programmes of potential interest to engineering, e.g. science magazine programmes such as Quantum, Beyond 2000 or Horizon, fall into category B.

The Australian universities are taking this matter very seriously. Staff are advised not to circumvent the process by recording off-air privately and then using these tapes in classes. At the University of Queensland, such behavior will be taken as a breach of the staff member's contract of employment that could be regarded as a serious misconduct for the purposes of the Universities Academic Staff Award. The climate is changing.

Informal video productions

While the level of student expectation in programme quality and production values rises steadily, there is a contradictory increase in the acceptance of video material produced at a very basic standard. This is a consequence of growth in the domestic video camera market and the corresponding use by many students of such equipment. It is increasingly common for students to use video for gathering and storing information from the field as part of their industry-based, final-year design projects [5]. Students are not self-conscious about showing this material during the formal presentations that form part of their course. They accept that it is an amateur production and presumably judge it for its content rather than for its production values. The students are now directly involved in the production process.

This suggests a two-tiered approach to video production values in the future. On the one hand, short, low-budget 'amateur' productions where the immediacy and the richness of the information content is sufficient to sustain audience interest. Some popular music videos and 'home video' programmes on television are helping to create an acceptance of such 'amateur' productions. In contrast, the place for polished, 'professional' material, either produced by the academic or taken from outside sources (e.g. off-air) will remain.

Material preparation

The concept of asynchronous communication via video has important implications for the way in which lecture material is prepared and presented. Engineering lecturers satisfy perceived student expectations by presenting material that is predigested and summarized via OHPs or developed on the blackboard. The notes of the lecturer, less the verbally presented explanations, are transcribed by the students. The engineering sciences, with their emphasis upon terse mathematical formalism and symbols, have been facilitated by and in turn encouraged this modality of presentation.

Discipline areas such as engineering design, manufacturing and management, where the concepts are understood and enriched by more descriptive material, suffer through this treatment. Either the material is over simplified to suit conventional note-taking expectations, or the quality of information transfer is poor. New theoretical frameworks for understanding and for presenting manufacturing systems [6] and engineering design [3] are emerging. Both these could benefit from the innovative use of video as an asynchronous medium for communication.

Vander Wall [7] reports a positive student reaction to use of video as a supplemental, teaching aid in presenting the more difficult concepts (e.g. 3D visualization) in a first-year graphics course. He notes that the most beneficial arrangement is to make the video material available for the students to use as and when required and not on a mandatory or required basis, i.e. asynchronously.

Further, domestic video technology has made low-cost recording and editing of lecture presentations possible. Videoed lectures do not replace the need for new lectures to be given year by year but rather they extend the utility of the lecture and the preparation that goes with it. Students, especially in the humanities, and delegates at conferences and workshops have used tape-recorders for many years to record presentations. Students will soon be asking for permission to video lectures on hand-held cameras for replay at their convenience.

CONCLUSIONS

Making a broadcast-quality video programme, or more especially a series, is a major undertaking. The academic as writer and/or producer must become a fully committed member of the creative team. The cross-cultural interaction of working with video-makers is both very stimulating and satisfying—and at times quite frustrating. Video programmes should be used creatively as aids to learning; it is not a matter of simply substituting the lecture for a video presentation.

Video is a pivotal medium for popular culture. The diffusion of video technology makes it accessible in engineering education to both lecturers and students. It affords many opportunities to make descriptive and visual material available asynchronously to students, thereby enriching their educational experience. In accepting our responsibility to guide and to facilitate the education of young people, we ignore the potential and the power of the video medium at our peril.

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REFERENCES

1. Radcliffe, D. F. and Holt, J. E. Integrating application's software into design courses. *Int. J. Appl. Engng. Ed.*, **4**(3), 259–264 (1988).
2. Holt, J. E., Radcliffe, D. F. and Schoorl, D. Design or problem solving—a critical choice for the engineering profession. *Design Studies*, **6**(2), 107–110 (1985).
3. Holt, J. E. and Radcliffe, D. F. Learning in the organizational and personal design domains. *Design Studies*, in press.
4. Wise, C. Agreement with Audio-visual Copyright Society, Memorandum from Joint ACDP/AVCC Committee, 6 August 1990.
5. Lee, T. Y. and Radcliffe, D. F. Engineering design education through industry-based projects: communication and information issues. *Proc. ICED*, Zurich, August (1991).
6. Kidd, P. T. Organization, people and technology: advances manufacturing in the 1990s. *Computer-Aided Engng J.*, , 149–153 (1990).
7. Vander Wall, W. J. A comparative study on the effectiveness and influence of required supplemental video teaching upon students' grades, course completion, visualization proficiency and course attributes, *Engng Design Graphics J.*, **55**(2), 10–16.