Experience with television courses for computer science teaching

By S. H. Lavington and J. S. Rohl
Department of Computer Science, The University, Manchester M13 9PL.

Manchester University have produced a series of video tape lectures about computer science. This article discusses how they were made.

Introduction
The Department of Computer Science at the University of Manchester is involved in presenting several short subsidiary courses, in addition to its normal 3-year honours B.Sc. teaching. These subsidiary courses fall under three main headings:

(a) Full-length subsidiary courses (one afternoon per week for three terms); these cover Algol programming and a choice of either Computer Design or Numerical Methods.
(b) Half-length subsidiary courses; these cover rather less Algol, plus some Computer Appreciation lectures.
(c) Summer School: this is an intensive 3-week residential course for graduate recruits to industry, and covers the whole spectrum of Computer Science.

There is also a call within the Regional Computer Centre for crash courses of 3-day or 5-day duration.

At present, a total of about 500 students per year are processed in these courses. They come from predominantly scientific backgrounds, with specialities ranging from Chemistry to Architecture. The number of students requiring some form of computer education is likely to rise rapidly, and will soon include undergraduates from the Arts side. To meet this heavy teaching load, much use has been made of pre-recorded television lectures, plus accompanying booklets. In particular, two 12-lecture course-packages have been produced on 'Programming in Algol' and 'Logical Design of Computers' (reference 1), and more are planned on Fortran, Computer Appreciation and Computer Applications.

This paper discusses some relevant television production techniques, and a general assessment of the usefulness of television in the context of computer education. The comments are based upon experience gathered over two years use of the 'logical Design' and 'Algol' courses, both at Manchester and at other Universities who have purchased the material. Details concerning the syllabus will be found in the Appendix.

Production Experience
The 'Logical Design' and 'Algol' series were produced by the Department of Computer Science in conjunction with the University of Manchester Television Service, using a reasonably well-equipped studio containing 3 cameras and a telecine unit. To keep costs down, animated films and location film sequences had to be kept to a minimum, and much use was made of reveal-captions, photographic stills, and a large magnet board. The magnet board proved to be very useful for building up programs and logical diagrams, and permitted a high degree of informal interaction between diagram and presenter.

Figure 1 shows an overall view of the magnet board during a break in rehearsal for a 'Logical Design' lecture. Some basic outlines have previously been drawn on the board and additional magnetic symbols are superimposed during the programme. Some of these symbols may be seen on the shelf just beneath the board. Caption cards were prepared using 'lettraset' or hot-press characters, and captions were arranged so that normally not more than five or six lines of text appeared on the screen at any one time. This restriction was necessary because of the large viewing distances between audience and television monitor that are often encountered during play-back. A typical caption card from the 'Algol' series is shown in Figure 2. The text restriction was potentially onerous with regard to displaying large sections of Algol program, but was overcome by using two cameras and a careful sequence of close-up and medium shots, with panning or zooming as appropriate.

With regard to diagrams and captions in general, it was found that the television format demanded considerable adaptation from normal blackboard standards. Thus, probably the most important part of programme planning consisted of discussions between the lecturer and the television graphics designer. The graphics designer, being unfamiliar with computer terminology, was able to highlight areas of potentially ambiguous or tedious visual communication, and assist the lecturer in producing a better plan. Surprisingly, the visual demands of television were in the end never felt to be restrictive; rather, they encouraged more concise and imaginative presentations.

There was another aspect of television which did place demands upon the lecturer, and this was the necessity for him to give accurate verbal cues. Shooting was continuous, with no facility for automatic prompting or subsequent editing, and so a half-hour's script had virtually to be learnt by heart. The presenter had to know which phrases were to be treated as camera cues, and which sections of script could be spoken rather more spontaneously. It was found
that one or two runs through normally constituted sufficient rehearsal for each programme. The lecturer normally spent about 20 man-hours in script preparation and production meetings prior to the full day needed for rehearsal and shooting of one programme. The total man-hours, including the day's shooting, spent by Television Service staff on each programme averaged about 146. The average cost of each half-hour programme consisted of £89 worth of material (video tape, film, graphics, etc.); a notional £150 allowance for studio overheads; and £92 for Television staff salaries. This brings the production cost of a complete 12-lecture course to about £4,000. This costing is based on 1968 prices. Salaries have increased considerably since then, but the Television staff at Manchester are now needing to spend rather less man-hours preparing for each programme. To the figure of £4,000 could be added an amount to cover the cost of the lecturer's time. Both the 'Algol' and 'Logical Design' courses have comprehensive 100 page printed booklets, and some allowance might also be made for the considerable time taken to prepare this material for publication. Figures 3 and 4 show pages from the two booklets, and serve to demonstrate the nature of the typographical and layout problems that were encountered.

Figure 3. Sample pages from the 'Logical Design' course booklet.

Figure 4. Sample pages from the 'Algol' course booklet.

Educational and Economic Justification

Having regard to the capital expenditure noted overleaf, have the two television courses subsequently justified themselves? Practically speaking, the answer must be 'yes', because the Computer Science Department just does not have available a group of lecturers with the time and inclination to give many repeats of the same lecture, week after week, throughout the year - all to the same high standard. Television also helps solve the timetabling problems of processing many students from several different Departments by, for instance, allowing simultaneous replay of different lectures to different parts of the campus.

Although the use of television makes possible the mounting of courses which would otherwise not be given, there are naturally the overheads of staff time needed to supervise and tutor each video replay. It was at first felt that much of this tutoring could be undertaken by research students, but experience has shown that the course-tutor needs to be a mature and sympathetic teacher, in order to encourage the asking of questions and offset the physical remoteness of the television presenter. Typically, each half-hour video replay is followed by a further half-hour of tutorial with the course-tutor, during which the students work through simple examples given in the booklet. When handled properly, this results in more factual material being covered and more learning taking place, per student contact-hour than was possible with normal blackboard-and-chalk lectures. It should be mentioned that an (unintentional) controlled experiment has shown that an unsympathetic and uncommunicative course-tutor can noticeably undermine this potential advantage.

The success of the system lies in the fact that the material of a 1-hour lecture was communicated very efficiently (in less than half an hour), leaving the remaining half-hour available for more direct (and, from the teacher's point of view, more rewarding) teaching.

Course examination results before and after the introduction of television appear to be much the same. They are difficult to compare precisely, because the television syllabus is more comprehensive and to a higher standard than was the previous material. In general, the number of abject failures seems to have decreased - probably due to the availability of comprehensive printed notes. A comparative factual-recall measurement was performed for a single 'Logical Design' lecture. The lecture chosen was number 5 (see Appendix), since this subject did not involve complicated diagrams, film-inserts, or apparatus. For the experiment, a class was divided in two, and the answers to simple factual questions then compared subsequent to one half viewing the television lecture and the other half being given the same material via a normal blackboard-and-chalk presentation - (same lecturer in each situation): Table 1 shows the average percentage success-scores, for the experiment conducted on two successive years with different classes of students. In 1969, the full class consisted of 60 Mathematics students; in 1970 the full class of 80 was made up of students from Mathematics, Liberal Studies in Science, Psychology and Zoology.

<table>
<thead>
<tr>
<th></th>
<th>Immediate recall</th>
<th>2 weeks later</th>
<th>3 weeks later</th>
</tr>
</thead>
<tbody>
<tr>
<td>Television audience (1969)</td>
<td>80%</td>
<td>-</td>
<td>56%</td>
</tr>
<tr>
<td>Blackboard audience (1969)</td>
<td>90%</td>
<td>-</td>
<td>63%</td>
</tr>
<tr>
<td>Television audience (1970)</td>
<td>71%</td>
<td>48%</td>
<td>-</td>
</tr>
<tr>
<td>Blackboard audience (1970)</td>
<td>93%</td>
<td>68%</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: Recall Measurement

In summary, Table 1 shows that recall scores are about 15% better for students attending a good live lecture. The live lecture, during which the student copied down notes, took about twice as long to cover the same material as was presented during the television programme. The difference in recall scores was not reflected in a similar difference in the number of passes at the end-of-year examinations, before and after the introduction of television. This suggests that the experience gained in the tutorial more than compensates for the lack of reinforcement which is normally gained by taking notes during a traditional lecture.
Student Reaction to Television
Students express approval of the visual presentation and conciseness of the television lectures. They are in favour of the printed booklets and find it helpful to read these before each programme. 31% of a sample class of 60 students felt that the pace of the lectures was rather fast, and a frequent comment is that it is difficult to maintain concentration. 64% of the audience felt that each lecture had attempted to cover the right amount of ground, whilst 26% thought that too much material had been included; the remaining 10% felt that too little was being covered. With regard to concentration, the technical quality of video play-back and the size and positioning of the television monitors, is important. Many types of video recorder seem to require regular maintenance, if the presence of distracting electronic interference during play-back is to be avoided. In conclusion, it has been found that under satisfactory play-back conditions and with an understanding course-tutor, the students are enthusiastic about television lectures and respond to the intellectual challenge they offer. On the other hand, a combination of poor play-back conditions and a distinterested course-tutor can produce a state of resigned neutrality to the whole exercise.

Conclusions
The teaching of certain aspects of Computer Science to non-specialists is likely to increase. Provision of the many courses that are called for cannot be undertaken without some aid such as television. Whilst a television course is not automatically successful in the educational sense, experience shows that the careful use of the medium produces examination results that are not noticeably different from those obtained from similar courses using more conventional teaching techniques. Plans are being made at Manchester to increase the use of television in computer education.

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Reference

Appendix
Details of the 'Logical Design of Computers' and 'Programming in Algol' Courses
A description of the aims and usage of these two courses is given in Reference 1. Outline syllabuses only are presented here.

Logical Design
Lecture 1: Introduction; binary numbers and functions of binary variables.
Lecture 2: Electronic digit - representation; diode-resistor AND and OR gates; practical points.
Lecture 3: Logical arrangements for serial addition; performance of a particular adder; the need for parallel adders.
Lecture 4: Techniques for parallel addition - (synchronous; self-timing; carry look-ahead; others); comparative performance.
Lecture 5: Negative number representation, and subtraction.
Lecture 6: Slow and fast multipliers; division.
Lecture 7: Storage, part 1: definitions; principles of magnetic recording; tape, disc and drum stores.
Lecture 8: Storage, part 2: operation, and organisation of core stores; other devices (thin films, flip-flops); complete memory-configuration for a typical computer.
Lecture 9: Design of a small machine, part 1: computers from a user's point of view; choice of word-length (form of an instruction, number-range etc.); how instructions are obeyed.
Lecture 10: Design of a small machine, part 2: function and address-decoding; choice of main store; function-list; design of accumulator and adder; its speed and cost using TTL integrated-circuit modules.
Lecture 11: Design of a small machine, part 3: central machine rhythm, and timing of orders; complete arithmetic unit logical connections; input and output devices in general; choice of a particular I/O device; complete machine cost.
Lecture 12: Use of computers: a binary loader for the small machine. Possible design-improvements, including: address-modification; high-level languages; peripheral-handling facilities. General comments; historical notes; course-summary.

Note: The intention was that the only course-requirement should be O-level in Mathematics and Physics. Despite this intention, some of the above material seems to be understood with ease only by students who have obtained a university entrance qualification in some science-based subject, or equivalent. If adequate supervision was available, it is felt that the 'Logical Design' course could be used in sixth forms, colleges of education and polytechnics.

Algol
Lecture 1: An introduction to the nature of computation; derivation of a computer model; a simple Algol program (to add 3 numbers).
Lecture 2: Transformations of the simple program of Lecture 1 arriving at one which will add any number of numbers; introduction to BNF.
Lecture 3: Arithmetic - the definition of the < simple arithmetic expression > with examples; some input-output procedures.
Lecture 4: Conditions - the definition of the < simple Boolean > and the < conditional statement > with examples; flow-diagrams.
Lecture 5: Control - the definition of the < for statement > and the < go to statement > with examples.
Lecture 6: Arrays and blocks - the definition of the < block >, the < array declaration > and the < subscripted variable > with examples.
Lecture 7: Complete definition of the < expression >s; comment conventions; fuller discussion of input and output (for Atlas and the ICL 1900 series) including character procedures.
Lecture 8: Introduction to procedures; value and name parameters; body replacement.
Lecture 9: Function procedures; full list of < specifier >s; philosophical justification of procedures.
Lecture 10: Recursion both in recursive procedures and recursive calls; Jensen's device.
Lecture 11: Discussion of what makes a 'good' program; efficiency; debugging.
Lecture 12: A case study.

Note: The 'Algol' series is normally accompanied by programming exercises, for which demonstrators are available to help sort out problems. In the full-year subsidiary course at Manchester each student is required to complete ten programs. The series is at quite a high standard and is suitable for use in courses leading to a degree or to professional qualifications. It is not likely to find much use in schools.

Further details concerning arrangements for acquiring the material may be obtained from the authors.