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MULTI-MEDIA SOFTWARE FOR TEACHING DISCRETE EVENT SIMULATION

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ABSTRACT

Multi-media software is being developed for an undergraduate introductory course to discrete event and visual interactive simulation. It is part of a larger project, funded by the U.K. Government, to provide computer based learning courses in various different subjects. The simulation course uses WINDOWS based software, called *Learn-OR*, which provides video, hypertext links and links to simulation software. The simulation module, covers: model structure, activity cycle diagrams, distribution sampling, model validation and experimentation.

1 INTRODUCTION

Simulation teaching has utilized visual and interactive simulation software for several years. The benefits of such software are well documented (Bell 1991, Bell and O'Keefe 1987, Belton and Elder 1991). However, this is useful for only the more practical part of the process of teaching simulation (although this is important). The notion of multi-media computer based interactive learning is that students can learn the basics of a topic, using their own particular learning style. They can work at their own pace from material that is potentially more interesting than can be normally delivered in lectures.

The U.K. government agency, which funds most of the degree level teaching, is currently engaged in a major initiative to increase efficiency and effectiveness in teaching by harnessing new technologies. A group representing the academic Operational Research (O.R.) community, bid successfully for some of this funding. The aim of the O.R. project, known as MENTOR, Elder and Belton (1992), was to provide seventeen separate modules, over a three year period, to cover most topic areas within O.R. The modules were to use multi-media computer based interactive learning techniques (Morariu 1988). This paper describes one of five modules to be developed in the first year of funding.

The literature of cognitive science and developmental psychology suggests a move away from the notion of learners as passive receivers of knowledge, towards being active builders of their own mental schema which contain their understanding (Glaser and Bassok 1989, Neisser 1976). Although current undergraduate teaching is sometimes innovative, the conventional approach, with the lecturer imparting knowledge from the front of the class room, does not encourage students to be active learners. When class sizes are small, it is not difficult for the lecturer to interact with the student to create an enquiring atmosphere in lectures, and to know enough about individual students in tutorial groups to motivate their own investigative learning. However, with large classes, a conventional lecture proceeds in a non-interactive manner, at the pace of the modal student (if the lecturer is skilful). In tutorials (which in the U.K. are mainly used to review worked examples and look at case material with subsets of students), it is usually not possible for the instructor to give attention to the particular learning difficulties of individuals because of the large number of groups and limited time availability. Thus students from large classes can become de-motivated.

Interactive computer based learning (if well implemented) enables students to learn via the route that interests them most (Kibby and Mayes, 1992). A multi-media interactive learning system is not a linear series of screens or video images, but instead is a multi-dimensional labyrinth to be explored in whatever sequence the student desires. Students can pause on material that they perceive to be difficult and skip over text they understand. The parts of the course they find interesting, they can explore in more depth.

As learning proceeds, exercises enable students to assess their own understanding, with the ability to reiterate earlier learning material if required.

Furthermore, information on individual students' progress, and success at worked examples, can be fed back to instructors via computer networks. The tutor is then in command of information about individual difficulties that can be reviewed during tutorial sessions. Less time should be required for reviewing lecture material and more time can be spent on the real purpose of the tutorial sessions: re-acting to students' problems and working through case material.

2 METHODOLOGY

2.1 Development of Multi-media Software

The group at Strathclyde, who are leading the project, reviewed various types of multi-media software that were available for the development of teaching materials. They decided that the computer based learning material should be made up of windows of explanatory text, linked to each other and to other materials such as video clips, illustrative computer programs, examples and exercises. They wanted software with the following characteristics:

- easy for authors to use in the development and modification of software;
- hypertext links (words shown in a different colour and linked to other text windows) so that students could look up definitions and descriptions of case studies or video material;
- buttons to link to other windows, computer programs, video material and exercises;
- the provision of maps (linked boxes representing blocks of text) of the teaching material so that the student could discover where s/he was going and know where s/he had been;
- the provision of assessment facilities on different parts of the module for students.

Most commercial software was found to be unsuitable because either there were no hypertext links or, if there were, they were difficult to use. None provided any student assessment facilities. The Strathclyde group therefore decided to develop their own software, on a contract basis, with a software house. This software, called *Learn-OR*, is developed in Borland Pascal using WINDOWS 3.1. It provides all the facilities listed above.

2.2 Workshops

The OR modules are being developed with a view to their widespread use in the U.K. University lecturers are, however, known to be idiosyncratic (particularly in the U.K.) and do not like to use other people's teaching materials. In order to help forestall any problems, workshops were arranged at the beginning and, in most cases, part way through the development of each module. Each workshop was attended by 15 to 20 people from different institutions.

The simulation group was quite enthusiastic and made useful suggestions for the addition and pruning of material. Several provided the team with course plans, exercises and software. Some expressed the view, however, that they would want to select parts of the hypermedia teaching material for their own courses and would want to add their own software or exercises to the module. There was clearly a need to make the examples and software exercises as independent as possible from the main explanatory text.

During the four months following the first workshop, the major part of the module was developed in the *Learn-OR* software. This was sent to interested academics to test out for themselves and make suggestions for amendments.

2.3 Testing in the Classroom

The software is being completed in the summer of 1993 and is expected, by our sponsors, to be in use in the autumn of 1993. There is little opportunity, therefore, for extensive testing on students. The plan is to test it on some graduate students from other disciplines who are currently unemployed. It will then be made available to those who attended and contributed to the workshops. These staff will be given training in the use of the authoring software so that they can modify the software for their own purposes. The authors of this paper will evaluate the course more thoroughly in their own institutions.

3 SIMULATION MODULE

3.1 Objectives

The purpose is to provide a simple introduction to simulation. The project is designed to reduce a 20 lecture course with supporting classes and laboratory sessions to five lectures. The computer based material provides the rest of the instruction. The course is aimed at undergraduates with a background knowledge of basic mathematical and statistical concepts and a familiarity with the use of computers, but not necessarily the ability to write computer programs. Students will need to be able to perform simple algebraic manipulations, understand what is meant by a discrete or continuous probability distribution and be able to calculate sample means and variances.

The aim of the course is as follows:

- to interest students in discrete event simulation and to motivate them to learn about it;
- to enable them to structure a model and provide an activity flow diagram;
- to understand what is meant by randomness and how to sample from distributions;
- to run simple models on appropriate software and interpret the results.

3.2 Overall plan

The first part of the course, shown in Figure 1, introduces a problem concerned with the design of a petrol station forecourt. There is video material and graphical simulation software. In order to stimulate interest, students are able to change the parameters and to explore different policies. This part of the module is concerned with structuring problems. The content and relationships in the model are related to the objectives and assumptions. Various examples, supported by video material, are analyzed to determine their activities, events and queues and the links between them. These are presented graphically as activity cycle or flow diagrams (Tocher 1961, Mathewson 1977). Several of the examples are derived from the textbook, Davies and O'Keefe (1989).

Figure 2 shows that the second part of the module is concerned with sampling. Students are shown how to sample from discrete and continuous histograms and from some common distributions. The module explains how to generate pseudo-random numbers but does not include complex rules or statistical tests for randomness. The same examples, as introduced in the previous section, are used to illustrate the concepts. Buttons in this part of the module will activate Pascal programs which generate numbers and sample from distributions.

Figure 3 shows that the final part of the module is concerned with the production of results and experimentation. Here the student learns about model validation, decisions about the results to collect and the statistical analyses of output. Students are able to run simple multi-stage queuing models in a program generator called GENNY which was developed by one of the authors (Ruth Davies) for use in teaching.

3.3 Examples and Videos

Video clips are to be stored on hard disks rather than on a CD ROM so that they can be changed and updated, as necessary. The video material will be transferred between institutions on Super JANET, the upgraded inter-university computer network in the U.K. Many

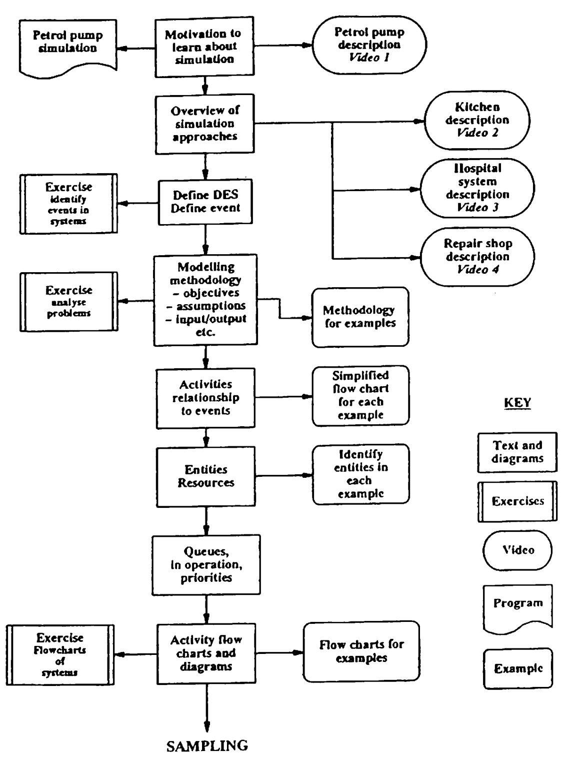

Figure 1: The modelling part of the simulation module

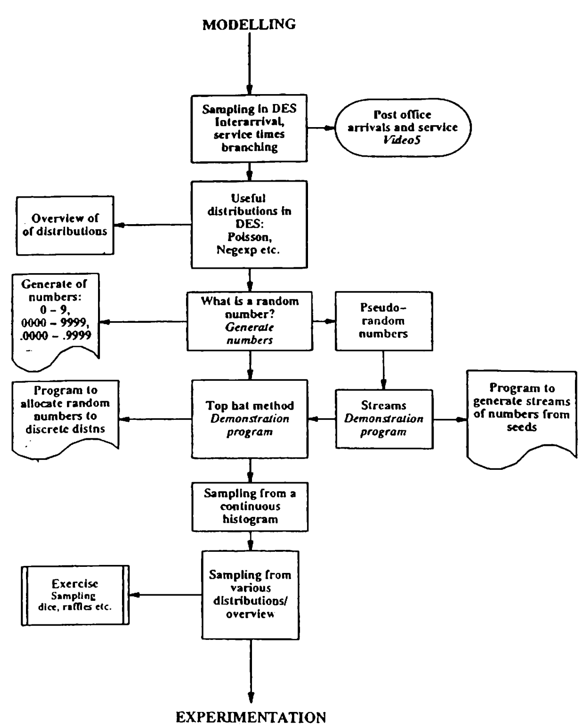

Figure 2: The sampling part of the simulation module.

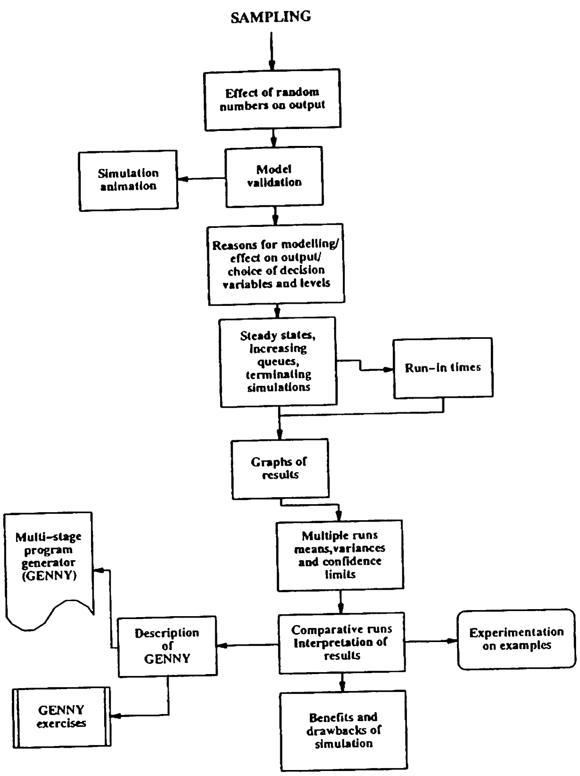

Figure 3: The experimentation part of the simulation module (see Figure 1 for Key).

institutions do not, however, have facilities for students to have video and sound reproduction in the student laboratories, either now or in the near future. Still pictures are, therefore, provided as an alternative to the film and written material to replace the sound.

Short video clips for the simulation module were chosen to illustrate various different concepts:

Queuing at a petrol station is a common experience for a large number of people. This shows a multistage queue: queuing for petrol and queuing to pay.

Preparation of breakfast shows a series of interdependent events: put kettle on, put toast in machine, kettle off, make tea etc.

A hospital system shows 'competing' groups of patients with different priorities requiring the same resources: hospital beds, theatre sessions.

A machine repair system is a closed system in which a machine breaks down, waits for repair, works and eventually breaks down again.

The post office system illustrates a multi-channel system with random arrivals and various service times, depending on the customers' requirements.

These examples are used to illustrate the way to structure a simulation, the use of activity flow diagrams, sampling and experimentation. Each time one is mentioned in the text, the student can view the case study description and video clip.

3.4 Use of hypertext and buttons

Each window of text is linked to the next one and to the previous one. The student is thus able to proceed in an organised way through the material. Some words are denoted as hypertext links. This permits students to look up definitions and explanations of particular concepts or to reference particular examples. The buttons on the screen enable students to call up computer programs, graphics, exercises or video material.

Figure 4 shows a screen where the main text explains how to sample from a continuous histogram. The student has activated the hypertext word 'random' and this overlaps some of the original text. S/he has also activated the hypertext words 'hospital' to show the hospital example video clip.

3.5 Software

The authors decided to use some simulation software that would enable students to experiment with some examples. The software had to be cheap (preferably free) and easy to use. There were two separate requirements:

- software that provided simulation graphics of the petrol station problem and enabled students to change the simulation parameters to see how it affected the results;
- software that enabled students to model simple situations and to analyze the results.

For the first, the authors are using software provided by one of those attending the initial workshop.

GENNY (mentioned above) is used for the second purpose. GENNY can model one, two or three stage queues with a choice from constant, normal, exponential and log normal for each of the arrival and server distributions. There are simple graphics which show queues building up and resources in use. The output provides graphs of frequency distributions of queue lengths, waiting times and resource use.

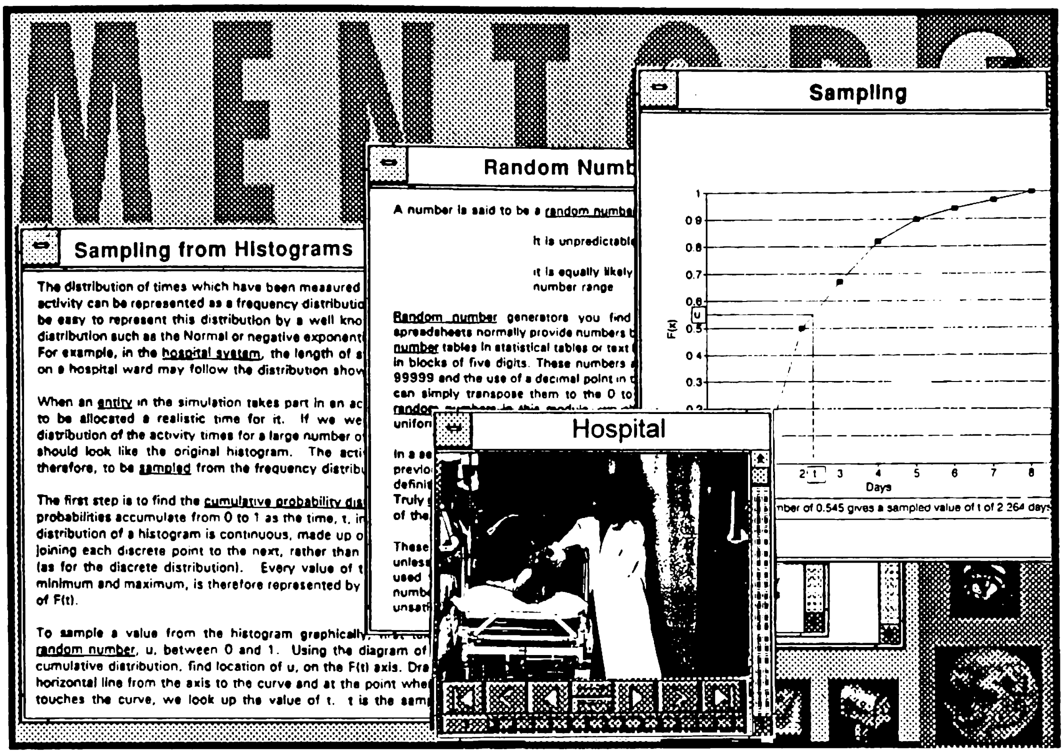

Figure 4: A picture of a screen showing Learn-OR in use.

3.6 Assessment

There are exercises throughout the module. Some simple exercises for students to test their own progress will be presented on a 'strip tease window'. In practice, this is more like dressing than a strip tease because at each click of the mouse, there is more information in the window. Initially the window would show just the first exercise, then when the student was ready s/he could click the mouse for the answer which is written under the exercise. There can then be another exercise and another answer and so on. Responses to other exercises call up different windows, depending on whether an answer is right or wrong.

Many of the exercises have no clear right or wrong answers. Students may write responses to these on a computer notepad, either to be viewed by the tutor, or to form the basis of class discussion.

4 DISCUSSION

This paper is reporting on some work that is part of a much a larger initiative in the U.K., where lectures are being replaced by interesting and, hopefully, stimulating courseware. The remaining lectures can be devoted to motivating students, adding to and updating the information in the module and dealing with queries. Simulation is a particularly appropriate subject to teach in this way as it is clearly enhanced by the use of video material and interactive computer programs.

It is easy to be too euphoric about the potential of this new mode of delivery. While much work is in progress in both the psychology and interactive learning arenas (Saloman and Globerson 1987, Tuckey 1992) there is little reported evidence of these methods actually improving student understanding. Furthermore, while some students gain from this method of learning, others (with different cognitive styles) may be disadvantaged. Intuitively it seems that the more flexible method of learning proposed here would be better than the conventional non-interactive 'passive' lecture style of delivery. It is our intention to attempt to obtain evidence to back our intuition.

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