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DESIGNING AND MANAGING A MASTERS DEGREE COURSE IN SIMULATION MODELLING

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ABSTRACT

This paper presents the authors' experience in establishing and running an MSc in Simulation Modelling Course at Brunel University. General information related to the aims of the course, entrance requirements and course structure is provided. Research currently carried out for dissertations is addressed as well as the career prospects for the students attending the course. Finally, the overall experience gained in managing the course is discussed.

1 INTRODUCTION

Despite many years of teaching and researching into simulation modelling, none of the MSc courses currently available in the United Kingdom focuses on discrete event simulation modelling. This fact is supported by a study sponsored by the Department of Trade and Industry (1991). The study revealed the following facts: the scope of teaching of simulation in formal education is very limited, the amount of teaching of simulation varies greatly and is often at awareness level only, computer packages play an essential role in the teaching of simulation but are difficult to absorb, awareness through education is not as great as it should be, publication on simulation is to the converted and training from other sources has limited impact. Some of the courses, mainly in the operational research or management science domain, usually contain not more than one simulation modelling module which inevitably implies only a brief encounter with simulation. A course that is comprised of a variety of simulation modelling modules, providing extensive hands-on experience with numerous simulation languages and simulators using a case study approach is not provided.

In an attempt to offer an alternative and further promote simulation modelling, an MSc in Simulation Modelling Course was established in 1993 in the Computer Science Department, at Brunel University. This advanced course primarily aims to give an understanding of the process of using discrete event simulation modelling as a problem-understanding approach, rather than as a technique that solves problems. The course is mainly designed for students with a good honours degree in a quantitative subject such as engineering, computing or economics.

Allied to the course is the Centre for Applied Simulation Modelling at Brunel University. The Centre's research activities, which contribute to the MSc course, are described by Paul and Hlupic (1994).

This paper discusses our experience in establishing and managing this course. Following general information about the course, the current research undertaken as the requirement for final dissertations is addressed. The career perspectives for the students attending the course are discussed. Finally, an overview of the experience gained in managing the course is presented.

2 THE MSC IN SIMULATION MODELLING AT BRUNEL UNIVERSITY

The main objective of the MSc in Simulation Modelling Course at Brunel University is to comprehend how simulation modelling is used in the process of problem-understanding and decision-making. The idea of problem-understanding is implemented through the building of a computer simulation model that represents the best understanding of the problem at the time. As such, the model is a debating device constantly under revision, that enables the problem owners to refine their understanding so that they are in a position to make better decisions concerning the problem.

The problem areas tackled by simulation are in business, economics and government. Such problems are complex and uncertain, so the model building process needs careful management. The second objective of the course is to understand how the management of the model building process can be handled in order to effectively provide a vehicle for problem-understanding.

The third objective of the course is to learn the basic skills and techniques associated with simulation modelling. These include conceptual modelling tools such as activity cycle diagrams, automatic program generators, visual interactive simulation modelling, simulation program structures, simulation software tools, the handling of stochastic input and output of the model, issues relating to model confidence etc. Whilst a grasp of the underlying concepts of these skills is essential, it is secondary to that of understanding the purpose of modelling.

The fourth objective of the course is to see the place of computer-based modelling systems in general and relate this to the wider issues of information systems and their development. Many of the complexities of simulation modelling, and methods of handling them, have a wider application. It is believed that students who have completed this course will be able to join in-house and external consultancies, software development groups or undertake further research. It is obvious that these skills as problem assisters and solvers will be in great demand in this increasingly complex and turbulent world.

The course can be taken either as a part-time degree spread over two years with work on the dissertation starting in the first year, or a full-time degree over one intensive year with the dissertation pursued during the summer. Students wishing to pursue the part-time degree must be in full-time employment in the United Kingdom.

Students who achieve a high standard in the taught part of the course and submit a satisfactory dissertation are awarded a Master's Degree. Work on a dissertation involves an in-depth study in the area of simulation modelling development and implementation. This may include a state-of-the-art review together with any appropriate practical implementation. Students who do not achieve the required standard in the exams are permitted to proceed to a Postgraduate Diploma. This usually involves a project more restricted to the description of a particular piece of work carried out to an acceptable professional standard.

3 ENTRANCE REQUIREMENTS AND COURSE FEES

Applicants should normally have a good honours degree in a quantitative subject such as computing, science, engineering etc. For candidates with a minimum of two years' experience in the computing industry, a good honours degree in any subject would be acceptable. Such applicants are treated by the University as special cases for entrance to Master's programme and are interviewed. Some preparatory work before entry to the course may be advised.

The fees for the course depend on whether a student is normally resident within the United Kingdom or the European Community. Students who are members of an EC country, and who have lived within the EC for at least three years prior to joining the course, will be required to pay home-based fees, which are approximately £2750. Fees for the part time course are approximately £1300 for year 1. Students who are not eligible to pay home-based fees will be required to pay a course fee of approximately £7995. These figures represent fees for the academic session 1993/94.

4 COURSE STRUCTURE

The course is structured around a common core of material comprising a Simulation Modelling Block and a Research Block. The Simulation Modelling Block comprises four modules: Simulation Modelling, Advanced Simulation Modelling, a Simulation Modelling Workshop and a Simulation Modelling Seminar. The Research Block consists of the Research Methods & Issues module and the dissertation. In addition to modules from the Simulation Modelling Block and the Research Block, students have to choose three options from the following modules: Advanced Information Systems, Artificial Intelligence and Applications, AI Workshop, Software Development Process, Advanced Aspects of Logic, Neural Networks, Applied Statistics, and Formal Basis for Computation. Table 1 summarizes the course structure.

A variety of teaching methods are used to teach the courses in the program. These methods include:

- Conventional lectures using an overhead projector and white board;
- *Case studies presentations* given by guest speakers;
- *Workshop programme* based on case study material taught in the specially dedicated computer laboratory and supervised by tutors. This method provides students with a considerable amount of practical experience in the application of various simulation software tools to specific problems.

- *Seminars* which involve student presentations and discussions about a particular topic;
- *Project supervision* which involves weekly sessions with at least one of the tutors during which progress on the dissertation work is discussed.

4.1 Simulation Modelling Module

The content of the Simulation Modelling module relates to the teaching of the basic concepts and issues related to simulation modelling such as: *Problem definition, Conceptual modelling* using activity cycle diagrams, *the Three phase method, Computer model development* using a program generator, *Random numbers* and *Statistical sampling, Design of experiments, Model validation and verification, Simulation project management* and *Professionalism and ethics* in simulation. Paul and Balmer (1993) gives a good idea of the coverage of the course.

Table 1: The Structure Of The Course

MSc in Simulation Modelling - Course structure
Simulation Modelling Block ~ Simulation Modelling ~ Advanced Simulation Modelling ~ Simulation Modelling Seminars ~ Simulation Modelling Workshop
Research Block ~ Research Methods & Issues ~ Dissertation
Three Options ~ Advanced Information Systems ~ Artificial Intelligence and Applications ~ AI Workshop ~ Software Development Process ~ Advanced Aspects of Logic ~ Neural Networks ~ Applied Statistics ~ Formal Basis for Computation

In addition, several guest speakers are invited to present simulation case studies and PhD students to report on their research. For this module, students are assessed entirely by project work, consisting of a practical modelling project and its associated report, and an essay on a simulation topic.

4.2 Advanced Simulation Modelling Module

The Advanced Simulation Modelling module concisely covers more advanced issues related to simulation modelling: *Project management* and *Critical Path Analysis, Inventory control applications, Replacement theory* and *Scheduling, Dynamic* and *Mathematical programming, Application areas of simulation* (eg. communications, military, manufacturing, computer systems), *World views* (event, process, activity, three phase), *Simulation modelling software environments* (simulation languages, data-driven simulators, program generators), *Simulation software evaluation, Soft system methodologies, Practical statistics, Descriptive sampling* and *Simulation gaming*.

One part of the course relates to students' presentations of 'hot topics' which this year included Virtual reality, Parallel simulation, Supercomputing, Chaos theory, Multimedia, Neural networks, Qualitative modelling, and Natural language understanding. Assessment for this module consists of an essay and a presentation on the specific topic, and an exam.

4.3 Simulation Modelling Workshop

The Simulation Modelling Workshop module provides an environment in which students experience practical work with a variety of widely used simulation software tools. It is intended to further develop programming and analytical skills as well as team work capability. Model building sessions provide a suitable training for conducting simulation studies, which provides skills needed for the final dissertations and the students' future career.

Simulation software evaluation sessions are also part of this module. They are designed to achieve proficiency in the use of various simulation software tools on the basis of detailed software evaluation using the evaluation framework provided. By the end of the series, students achieve a working knowledge of several simulation software packages such as SIMFACTORY II.5, SIMSCRIPT II.5, MicroSaint, SIMAN/Cinema, Taylor II ProModelPC, SLAM II and MODSIM II. Students are assessed on the basis of the individual and group projects on simulation software evaluation and model building using the above packages.

4.4 Simulation Modelling Seminar

The aim of the Simulation Modelling Seminar module is to enable students to share their knowledge about various aspects of simulation and problem solving in general, further developing presentation, writing, listening and discussion skills. By the end of the series students should acquire a broader understanding of simulation modelling in general and its modelling tools. It is expected that this type of teaching encourages

individual activity and student interaction as explicit contributions to individual leaning.

A variety of topics are researched and discussed. Some of these topics include: Effective communication, Problem solving methods, Learning with understanding, Creativity, Model generation issues in simulation support environments, Data-driven generic simulators, Graphics in simulation, Simulation and Artificial Intelligence, Simulation in manufacturing, Cellular simulation and Event graphs in simulation modelling. Students are assessed on the basis of an exam, contribution to discussions and participation levels in the seminars.

5 DISSERTATIONS

In the current academic year there are 11 students attending the MSc in Simulation Modelling Course. They have already started working on their final dissertation. All projects involve collaboration with industrial and software companies, government institutions or other academic departments. For example, three projects are being carried out in collaboration with the Department of Manufacturing and Engineering Systems at Brunel University. One of these projects relates to the application of expert systems capabilities to simulation software, with the aim of investigating the potential of linking simulation software and expert systems to support manufacturing engineers in modelling manufacturing systems during the design phase.

Another project aims to investigate the suitability of modern simulation software for integration in an object-oriented information environment developed for the design and analysis of manufacturing systems. A further example relates to the project which aims to investigate the nature of a flexible simulation environment for manufacturing systems design. This environment should be capable of increasing the level of detail and scope to be incorporated in the model as the design cycle progresses from conceptual to detailed models, with minimal effort, and avoiding duplication of modelling and data collection effort.

Several projects are in the area of the application of simulation to the health service in collaboration with the Department of Health Economics. One project relates to the simulation modelling of therapeutic alternatives, in terms of the patterns of health service resource use and patient outcomes, associated with adjuvant endocrine therapy and chemotherapy in women with early breast cancer. The further aim of this project is to identify the key costs and clinical parameters required for a cost-effectiveness analysis. Another project in this area relates to the employment of modelling techniques in the economic evaluation of medical technologies using data from a typical economic evaluation such as the use of interferon in the treatment of chronic active hepatitis.

An industrial project involves the simulation modelling of a slow sand water treatment process in order to investigate alternative working methods with regard to sand handling, and to assess the scope for improving the efficiency of labour and plant resources used in filter bed maintenance.

A research project aims to create an interface for the graphical description of simulation models using activity cycle diagrams. This interface will allow the user to interactively build flat models on the screen with guidance from the system. The models are built using the icons proposed in the diagramming technique, and they can be stored for later correction or reuse. The models thus created should be able to interface with a program generator currently being developed as a PhD research project.

Another example of an MSc dissertation relates to a comparative analysis of the procedural and object oriented programming techniques in simulation modelling. The comparison will be based on the various simulation models developed both by object oriented simulation software tools (eg. MODSIM II) and procedural simulation languages (eg. SIMSCRIPT II.5).

Three of the remaining projects are in the financial sector, a hospital model, and an industrial application in Greece.

6 CAREERS

Future career prospects for students attending the MSc in Simulation Modelling Course at Brunel University is a paramount issue, especially now when the recession has taken a high toll in the U.K.. Information about the demand for professionals who are highly specialized in simulation modelling is constantly being collected during conversations with representatives of industrial companies, simulation software suppliers, consulting companies and other educational institutions. It appears that there is a great need for properly trained simulation specialists on the job market. Support for this claim is found in the DTI Study (1991), which revealed that one of the main obstacles to the more widespread use of simulation is a lack of proper education and training of simulation specialists.

Although at the moment it is too early for our students to take permanent jobs, it is believed that once they submit their final dissertations, they will be in a position to become employed in a couple of weeks or months. The main reason for this belief is the students'

sound knowledge of methodological issues of simulation, a working knowledge of several simulation software tools and practical experience gained through their work on their final dissertations, which offers a rear combination of skills.

7 EXPERIENCES AND CONCLUSIONS

Although the MSc in Simulation Modelling Course at Brunel University is in the first year of operating, it is apparent that it offers an unique combination of teaching of both theoretical and practical aspects of simulation modelling. The use of simulation modelling in the process of problem-understanding and decision-making is the basic paradigm on the basis of which the simulation modelling process is taught. The use of various visual interactive simulators and program generators in addition to simulation languages, enables students to get significant modelling experience during the course. Attention is also given to covering general modelling aspects such as problem definition and understanding, improving model confidence, experimental design and interpretation of simulation output results.

In general, the course is designed to answer the demands from industry for properly educated simulation specialists, and therefore we believe that our students have very promising career perspectives. We hope that the current and future generations of students attending our MSc in Simulation Modelling will significantly contribute to the further popularisation and utilisation of simulation modelling.

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