DISCOURSE:
The Design and Production of Simulation-based Learning Environments

Kenneth Tait
Computer Based Learning Unit,
The University of Leeds, UK

Abstract
A component of the Discourse project addresses the tools required for the design and production of multimedia simulation environments for learning. The educational and training use of simulations has two drawbacks: most simulations are designed and produced as single applications; and learners have difficulty in exploiting the learning opportunities presented by simulations. The work addresses these two aspects by developing a systematic methodology for the design and production of a simulation based on an abstract representation of the model which drives the simulation, and by embedding the resulting simulation in an environment which supports pedagogically beneficial learning activities and gives support to the learner by proposing useful tasks, encouraging prediction, and providing explanations which elaborate the simulated events. These aims are ambitious, but progress to date is encouraging. Equations for a model can be derived directly from a bond graph representation, and this can be developed into a simulation by the systematic addition of an animated diagram and display mechanisms for graphs and values using generic tools. An entity-relation graph (such as a bond graph) suitably annotated by an author and combined with a graph interpreter and a task space can provide the knowledge-base for explanation and question answering using techniques already developed.

1 INTRODUCTION

In building and using a simulation-based learning environment there are four aspects to be considered. Creating the model which drives the system, making an executable model into a controllable simulation, adapting or redesigning the interface to promote learning, and providing learner support. This is illustrated diagrammatically in Figure 1 where the learner support has been shown as a further layer surrounded the learner interface. This is the typical situation where the learner support is provided through teachers or trainers. Where the learner support is provided as part of a computer-based learning environment then it is likely that the learner support will be intimately linked with the learner interface, though it remains important to recognise the two separate functions: one of allowing the learner to operate the simulation and the other of helping the learner to learn from using the simulation.
The model at the centre of a simulation-based learning environment is often nothing more than a set of mathematical equations. Such a quantitative model is made executable by adding a solver which when given an initial state can calculate the next state after a small interval of time. By iteration a succession of states is generated which describe the behaviour of the model over time. Qualitative models operate somewhat differently, but in essence they serve the same role.

An executable model provides all the raw data but may be awkward to use and manipulate as a simulation. A simulation has, in addition to the model, a convenient means of setting parameters of the model, specifying the initial state and of displaying the behaviour in a more readily understood form through, for example, graphs and animation. The facility to change the parameters while the model is running can provide dynamic control.

A simulation which is to support learning needs a richer interface. The assigning of values to parameters, the specification of initial conditions and the control during execution need to be achieved in ways which directly correspond to the concepts or procedures that are to be learned. Thus, although a change in the behaviour of a model of part of the human body may be achieved by altering a parameter value, medical students may need an interface which allows them to achieve this same change by apparently controlling the amount of a drug administered. Similarly, a simulation of a chemical plant should, for training purposes, be managed through an

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**Figure 1** Simulation-based learning environment