# SimTutor: A MULTIMEDIA INTELLIGENT TUTORING SYSTEM FOR SIMULATION MODELING

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## ABSTRACT

SimTutor is a multimedia intelligent tutoring system (ITS) for simulation modeling. Multimedia systems are now de facto standard on personal computers and increasing number of intelligent tutoring systems incorporate multimedia systems to enhance interaction with students.

SimTutor provides a graphical environment in which the student can practice conceptual model development and interact direct with different simulation modeling software. We used multimedia systems to enhance the pedagogy and for incorporating different strategy into the courseware design. ITS components are accessed through the graphical user interface, allowing them to be developed independently. The modular architecture allows for interoperability of applications with the same event changing protocol. An object-oriented approach is adapted to allow the system to evolve and to flexibly change the data.

## 1 INTRODUCTION

The increasing proliferation of multimedia authoring tools has made it easier to quickly produce interactive multimedia courseware. Intelligent multimedia technology has enormous potential in the realm of simulation modeling education, especially when combined with virtual reality technology. The design of instructional systems reflects the technological advances. They provide a rich means of presenting interactive instruction and can be used as instructional aid. With the increasing demand for adaptable and extensible instructional systems, the development requires tools that are generic and reusable.

The emerging technologies that are contributing to training and education include intelligent tutoring systems, instructional gaming systems and interactive training simulation systems. Multimedia presentation is used as instructional aid during tutorials and for enhancing the pedagogy contents of the tutorial.

Instructional media selection was based on ease of use and adaptation for simulation modeling. The fundamental consideration for using multimedia is what topic in the course curriculum could be demonstrated by application of multimedia techniques? This paper presents development of SimTutor, an interactive intelligent tutoring system.

SimTutor combines intelligent tutoring with multimedia systems, for facilitating learning simulation modeling. A description of the architecture is presented, which consists of a "blackboard" a multimedia knowledge base, the instructional module and the student. The modular architecture allows for interoperability of these components and allowing them to be developed separately. An object-oriented approach is adapted to allow the system to evolve and to flexibly change the data. We conclude by describing the instructional strategy and implementation method.

Incorporating multimedia systems into ITS allows the user to easily navigate through the instructional units. Additional use of color, auditory and visual clues is used to highlight important aspects of simulation modeling processes. This "modality" effect improves working memory and enhances performance (Baddeley, 1992).

### 1.1 Integrating Multimedia

The delivery platforms for SimTutor is currently on a personal computer, this supports limited input from multiple channels. The current channels are keyboard, mouse, microphone and video. The future implementation would be over a network and the Internet. Advantages of using multimedia objects for simulation modeling include:
1. It can be used to emphasis logical relationship between simulation objects.
2. The problem being modeled can be decomposed and be represented as a small logical unit.
3. Multimedia objects may be included in model representation classes

This inherent user interactivity makes multimedia systems ideal for teaching simulation modeling. By using multimedia techniques, students could gain insight and understanding of the basic building blocks essential to simulation modeling development.

## 2 SYSTEM ARCHITECTURE OF SimTuor

The architecture is based on the blackboard model proposed by Engelmore et al. (1988). Blackboard architecture is characterized by modularity and is commonly used for dynamic instructional planning for intelligent tutoring systems (ITS), (Murray 1987, and McCalla et al. 1990). There are four main components to SimTutor: the domain model, pedagogy model, student model and graphical user interface. The three ITS models - domain, student and pedagogy, share the same knowledge base providing for reusability.

### 2.1 Domain Model

The domain model is represented as expert knowledge components. The human expertise has been encoded in a knowledge base and represented in small frames. The domain knowledge contains principles, procedures and techniques for conceptual modeling and statistical analysis. It consists of encapsulated rules, which can be triggered during the tutorial. The rules determine the performance of the learner and provide appropriate responses. The encapsulated rules consist of:

1. Student rule: It uses the current task to generate the next operation. It relates the current tasks to the classified structured tasks in its knowledge base. It also processes a status function, which can be used for providing appropriate help.
2. Operational rule: These rules specify operational tasks behavior that must be satisfied before the intelligent help is triggered. It can be represented as: operation {*conditions*}. The rule can also trigger other functions if the condition cannot be satisfied.
3. Procedural rule: It is used to specify the tutorial operation to be executed when the learner satisfied certain conditions.

The domain model does not provide individualized explanations as to student's queries.

### 2.2 Student Model

The student model may be defined as a sequence of actions performed during tutorial. It consists of sets of possible behaviors. This model represents the students' knowledge and maintains their level of performance. The student model provides the learner with different problems based on the user "overlay*"* model. The "overlay" model describes the learner in relation to its interactions with the tutorial and competence level (Ohlsson, 1993). The structure of the student model may be derived from the problem solving behavior of the student, and skill level attainment, i.e., novice to expert.

### 2.3 Pedagogy Model

The pedagogy model specifies how the student should be taught. Knowledge is hierarchically structured into small units, and each unit can be displayed as set of object on the same frame. Pedagogy model also contains some learning decisions. It controls the selection and sequencing of topics and introduces new topic. Cumming and Self (1991), suggested that choosing an appropriate teaching strategy and its presentation requires knowledge about the student's tutorial needs. The following didactic styles were incorporated into the tutorial:

- Drill and practice - is basically a problem solving exercise and provides immediate feedback
- Case Studies - Students are presented with a real life problem and are asked to solve it. Students may also be presented with video footage of the case study
- Successful Refinement - the curriculum contents are arranged in order to increase students level of understanding.

The pedagogy model provides the courseware author with a graphical environment to set up series of simulation and modeling exercises. SimTutor has facilities for setting up of exercises for the student and for learning conceptual modeling.

### 2.4 User Interface

The graphical user interface (GUI) provides a uniform representation of the user interface object. The user interface can be used to display high-resolution pictures, digital video images, and hypertext with graphics, standard texts and color graphics. The GUI is also used as a browser for tutorial units link information.

Shneiderman (1982, 1983) introduces the "direct manipulation" dialogue to describe GUI that are characterized by:

- continuous representation of the objects,
- physical actions or labeled buttons instead of complex syntax,
- rapid incremental reversible operations giving rise to immediate viable impact on the object.

Different color and graphic can be used for various contents of simulation modeling to improve comprehension and for conceptual modeling. It can also facilitate discrimination among multimedia objects and to separate simulation processes. Cueing strategies such as the use of color, font style changes, size changes, underlining boldface character and border style helps to make the tutorial more effective (Shneiderman 1987).

Our design is based on direct manipulation in order to reduce the student's need for semantic and syntactic knowledge. The GUI allows the student to generate and browse multimedia objects.

## 3  IMPLEMENTATION OF MULTIMEDIA TUTORING SYSTEM

### 3.1 Theoretical Background

Pedagogy contents of simulation modeling tutorial can be aided by using visualization, animation, static and dynamic images, and digital video images (DVI). Bell and O'Keefe (1987) postulate that simulation modeling is amenable to multimedia objects due to graphics and visualization used by most simulation modeling packages. Animation of simulation modeling processes is a potential form of demonstration and to visualize contents of the problem being modeled.

The approach we adopted is to first build the graphical/visual version of the model, which demonstrates how the real life model works. Digital video images may also be used to reinforce problems highlighted by other approaches.

Simulation modeling involves representing the physical elements of the real life problems and subsequently building the model. This involves using different graphical objects for representing the physical elements of the real life. This results in connecting graphical objects with the objects that they represent. Animation may be used to describe how the physical elements perform. Courseware may be presented by using video presentation with minor texts or graphic presentation with minor texts.

SimTutor intended to be used for teaching the basic aspects of simulation modeling course at Brunel University (Paul and Hlupic, 1994). The course modules were classified into pedagogy sequence by:

1. Simulation modeling processes were structured into smaller module specifying a simulation task
2. A hierarchical representation of model building processes, demarcating conceptual representation and statistical analysis.
3. Conceptual models representation is supported by a simulation software package

These representations allow modularity and each composite part is independent of the other. The advantages of this architecture are its simplicity and object oriented nature, plus its usefulness as an integrated courseware-authoring tool.

SimTutor provides interactive capability for model development processes and analysis. Different types of multimedia objects are utilized at different stages of simulation modeling study. SimTutor allows for:

- Direct manipulation of three dimensional graphical objects of real life problems, events and their sequence
- Animation of the real life model to enhance understanding

- Use of different color to show relationship between the system being investigated and the simulated system

SimTutor consist of the following modules:

Module 1: Simulation methodology – presents concept of simulation modeling

Module 2: Simulation software package(s) – teaches software for building models

Module 3: Statistical aspects of simulation modeling - teaches statistical approach to simulation experimental design and analysis

Module 4: Case studies – presents various real-life problems and solutions, linked to the above modules.

Module 5: Exercises and tests – linked to all modules.

Tutorials are presented by using combination of kiosk based presentation and tutorial path, which depends on the learner task and on the pedagogical sequence.

### 3.2  The Uses of Multimedia for Teaching Simulation Modeling

Typical computer based instructional system entails utilization of graphics and texts. Incorporating multimedia features into teaching simulation modeling involves the use of audio-visual objects into system. The use of multimedia for teaching simulation modeling offers the following advantages:

1. Provides capability of utilizing different media
2. Addition of animated tasks
3. Enhances reduced cognitive load of learning the tasks
4. Provides alternatives during learning
5. Improves interaction
6. Reuse of media objects
7. Uses sound as an effect and as a narrative accompanying some tasks.
8. Enhances learning experience

With the availability of different authoring tools, multimedia features can easily be incorporated into the instruction. This method could help the learner to develop an understanding of the task being trained. An alternative to this approach is to integrate virtual reality into some aspects of teaching simulation modeling.

### 3.3 Example for Building an Activity Cycles Diagram

We used the "Pub" example (Clementson, 1991, and Paul, 1993) to illustrate modeling with activity cycles diagrams (ACD). ACD uses two symbols to describes the life cycle of the systems entities which could be either in an active state - processing or be in a queue - waiting, as represented in Figure 1. The tutorial system takes the student through the following stages:

**Step 1:**

I.  Identify systems activities and queues

II. Decompose the life cycle by activities

III. Select different colors to represent activities and queues

IV. Select graphical objects or images of the entities - man, barmaid and glass

V. Identify each life cycle of each entity as shown in Figure 2

VI. Draw life cycle of each entity

VII. Animate the life cycle of each entity

The student can replay the animation or proceed to the next stage. The possibility of replaying the animation enables the student to study the interactions of the objects in details.

**Step 2:**

The interrelationship between each life cycle in now connected together as shown in Figure 2. Then, the whole life cycle of the ACD for Pub is animated.

Tutorial system allows the student to progress sequentially through the tutorial units and can adapt the tutorial to his level. There are three teaching sessions embedded into the tutorial system. The teaching sessions include tutoring, practicing and browsing. The student controls the practice session and it allows the student to either repeat a tutorial unit or carry out the exercises. The browsing session allows the student to view the available information or elucidate a "hotword" in the text.

SimTutor can assess the extent to which the teaching has been successful. This was achieved by using skills and knowledge checks based on each session of the tutorial. Figure 3 illustrates a typical exercise as it is presented to the student in the conceptual modeling test session. Students are asked to identify all the entities and events of a case study whose ACD is graphically displayed. The learner can either have immediate response or check their check their answers at the end of each exercise. The student's responses can be used to continually improve the tutorial and increase student's learning.

The tutorial is stored in ToolBook "books" A "book" is a ToolBook object, which consist of "pages" and multimedia objects. A unit lesson consists of one or more pages. Tutorial is hierarchically structured into topic contents. Each unit can be displayed as consistent set of object on the same page.

## 4 MULTIMEDIA KNOWLEDGE BASE

SimTutor consists of multimedia knowledge base for storing several multimedia resources. The knowledge base consists of some multimedia representation of simulation modeling and case studies.

Multimedia objects are linked to a frame and can be manipulated by a program. The knowledge base consists of the following: graphical objects with texts and audio, digital video images with text and audio, hypertext,

animated tasks, animated sequence, and examples of simulation modeling case studies. Using one of the following methods can be used to retrieve multimedia objects:

1. Indexing - Media objects are stored in the knowledge base according to their semantic classification. Each media object has a unique identifier, which can be used to query the knowledge base. This facilitates the structuring of the media objects in the knowledge base. The classified indexed file allows for rapid random access.
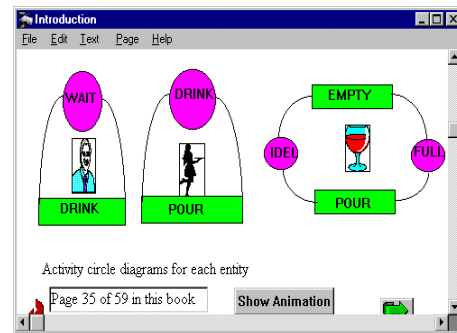


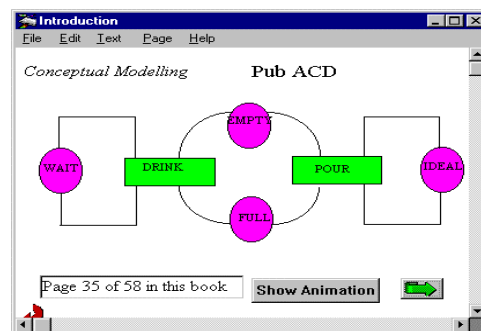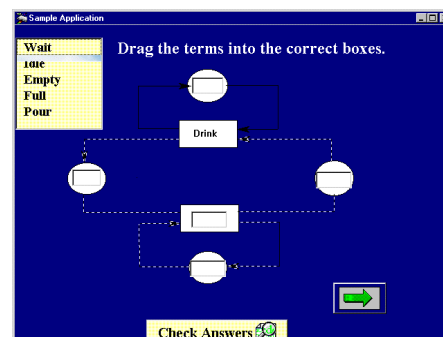Figure 1: ACD for each entity



Figure 2: Pub ACD



Figure 3: Conceptual modeling test

2.   Browsing and retrieval - The query presented by the learner is used to access the knowledge base. Selecting the node from the tutorial tree provides browsing.

The knowledge base is represented by using integrated "frame system" organized into hierarchical structure. The structured "frame" consists of tutorial tasks and subtasks represented in a semantic network (Pawlak, 1995).

## 4.1 Adaptive Instruction

The process of building a conceptual model requires the student to use an appropriate simulation modeling strategy. SimTutor could adapt its contents to both the student's knowledge level and requirements. The pedagogical content integrates all the four modules described and to the functionality of a simulation modeling software package. Adaptive instruction is based on the student's feedback loop, which evaluates the tutorial session and performance. Students performance was based on error message and help requests.

## 4.2  Evaluation

SimTutor is not fully evaluated, but primary evaluation is concerned with knowledge, skills, contents and presentation. The search engine is not being fully implemented, therefore it is not possible to do an exhaustive search. Further extensions are planned to improve this, and to introduce increasing levels of intelligence. The learner completing the question and answer session can measure the extent of the teaching objective. Outcome of this evaluation has been valuable in the modification and fine-tuning of the system. There are considerations to incorporate virtual reality into the pedagogy content.

## 5 CONCLUSIONS

This paper has described the design and development of SimTutor for effective tutoring of simulation modeling with multimedia support. An intelligent multimedia tutorial system depends on development of programs that understand the student's background knowledge and is adaptable to the needs of different learner. An ideal instructional system would adapt its contents and instructional method to the learner levels.

The main features of SimTutor are its ability to incorporate multimedia objects into intelligent tutoring systems components. It also emphasis the functional contents of simulation modeling in terms of simulation processes, functionality and multimedia objects. SimTutor supports classroom teaching and learning from

textbooks. This could help to extend simulation knowledge by revision of tutorials and application of new methodology or simulation modeling software package. The use of multimedia objects during tutorial presentation will enhance all aspects of the tutorial system and the pedagogy contents of the simulation modeling course.

Combining multimedia objects with more constructive tools can significantly increase the effectiveness of using SimTutor as an instructional tool. These tools should not only allow students to create model representations that are interesting to them and could be used in other kinds of contexts.

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