

Developments In Business Simulation & Experiential Exercises, Volume 23, 1996

THE DESIGN OF AN ITS-BASED BUSINESS SIMULATION: A NEW EPISTEMOLOGY FOR LEARNING

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ABSTRACT

This paper discusses the design and use of an intelligent tutoring system (ITS) for computerized business simulations. It is argued intelligent tutoring systems are a natural complement to computerized business simulations and could significantly enhance their pedagogical effectiveness. The use of ITS as an instructional technology and its success are reviewed. A fundamental model for an ITS-based business simulation is presented. The user interface and the linkage between the ITS and the simulation are examined. It is recommended the ITS consist of three distinct modules: expert consultant, diagnostic testing, and pedagogical support. The integration of ITS with business simulations offers a new epistemology for learning, the significance of which has yet to be fully understood.

INTRODUCTION

The purpose of this paper is to consider the potential role of an intelligent tutoring system (ITS) within a simulation environment and to discuss the design elements of such a system. Intelligent tutoring systems are not new, they have been under development and evaluation in multidisciplinary laboratories of top scientists in physics, computer science, engineering, and psychology for over a decade.¹

Both the ITS and simulation & gaming research communities focus on facilitating or improving learning but surprisingly there is little dialogue between the two communities. Notably, there has been almost no research papers on ITS in the ABSEL conferences and in the journal of Simulation and Gaming over the past ten years! One explanation may be the two communities focus on different stages of the learning process.

Consider the apprenticeship model of learning by Collins, Brown & Newman (1987) in which four stages are identified: (1) Modeling; (2) Coaching; (3) Fading; and (4) Reflecting. *Modeling* occurs when the apprentice (student) observes the master (teacher) illustrating a model or process,

which could be a simulation. *Coaching* involves the teacher advising and directing (mentoring) the student while the student is attempting to work with a model or simulation. *Fading* is when the teacher's assistance is reduced as the student becomes more comfortable with the process and performance improves. *Reflecting* requires the student to evaluate his/her own performance and assess learning.

The simulation researchers have concentrated on *modeling* and the pedagogical process of using the simulation with some attention to *reflecting* by students as a way of learning from the experience. Experiential learning or learning by doing is the modus operandi. The instructor's involvement in *coaching* the students and the process of *fading* are given relatively little attention in the simulation literature. There is an assumption that the instructor is teaching or coaching the students and providing constructive feedback in the process of using the simulation. But the way this is done and the extent to which it is done is not clear. In sharp contrast, intelligent tutoring system (ITS) researchers focus primarily on *coaching* the student, with some attention to *fading*, but very little detail on modeling or reflecting.² ITS research deals with the most effective ways to intervene constructively and guide students that are having trouble performing a certain task (i.e. coaching).³ In this paper we will try to link the pedagogical advantages of the ITS to business simulations to develop a new epistemology for learning.

WHAT IS AN INTELLIGENT TUTORING SYSTEM?

Intelligent tutoring systems are instructional software programs with the abilities of a human teacher, working on a one-on-one basis with the student, carefully diagnosing what the student knows, how the student reasons, what deficiencies exist in the student's knowledge, and suggesting ways to help the student to

¹ Garcia, Anne L., "Intelligent Training Systems: Smart Tutors", Bulletin of the American Society for Information Science, August/September 1990, p.8.

² Parkes, A.P. and Self, J.A., "Towards Interactive Video: A Video-Based Intelligent Tutoring Environment". In Frasson & Gauthier (ed), Intelligent Tutoring Systems (Ablex Publishing Corp. 1990), p.56

³ Ibid., p.56.

best learn the subject material.⁴ Intelligent tutoring systems are a significant step beyond computer-assisted instruction (CAI). An intelligent tutoring system is CAI with artificial intelligence in the knowledge domain and in teaching pedagogy.

Burns and Capps (1988) described three types of intelligence that are necessary for a CM to become intelligent. First, the subject matter must be known well enough by the ITS for it to draw inferences or solve problems in the domain, i.e. it must be an expert system. Second, the system must be able to assess a student's knowledge of the subject matter, i.e. is the student doing what the expert would do? Third, the system must be able to effectively tutor the student and reduce any differences between the student's performance and that of the expert's.⁵ The tutoring system must have effective teaching strategies and be articulate enough to help the student learn and improve his/her performance.

Extending intelligence to teaching strategy, a fourth type of intelligence is needed, i.e. the ability of the system to improve its teaching effectiveness with time and experience. The system must have control over its tutorial strategies, determining the best time to interrupt a student's problem-solving activity, what to say and how to say it.⁶ The more students the system tutors, the more intelligent (more effective) it will become as a tutor. Just as a human teacher, it will learn from experience (store in its database) the suggestions and advice that helped students and those that did not seem to work. This would require the system to consider and record the background of the student it is tutoring and modify its teaching strategy, if necessary, based on this information and its own experiences.

HAVE INTELLIGENT TUTORING SYSTEMS BEEN SUCCESSFUL?

Intelligent tutoring systems have been used on a limited bases for more than a decade, but are now emerging from research laboratories in a wide range of areas from foreign language skills and reading, to engineering and optics.⁷ The reviews on learning effectiveness are mixed, yet it is expected that in the 21st century we will see artificial intelligence become a major pedagogical tool.⁸

Shute (1990) offered two fundamental reasons for the mixed reviews on intelligent tutoring systems. Many of the ITSs were designed by seat of the pants" engineering and intuition regarding system components, (Koedinger & Anderson, 1990). Second, many of the evaluations were lacking systematic control groups, e.g. Baker (1990) and Littman & Soloway (1988). Bonar, Cunningham, & Shults (1987) argued that most ITSs evaluated prior to 1987 were not only complex and unwieldy, but contained fundamental design flaws related to the use of knowledge within the intelligent tutoring system. Specifically; these systems did not allow for additions of new domain knowledge or new approaches to the pedagogical tasks.⁹

Recognizing some of the deficiencies of the past studies with evaluating the pedagogical effectiveness of ITSs, Shute (1990) selected four simulations to test that were well designed, these included: (1) The LISP tutor by Anderson, Farrell, & Sauers (1984), teaching Lisp programming skills; (2) SMITHTOWN by Shute & Glaser (1990), a tutor for scientific inquiry skills in microeconomics; (3) SHERLOCK by Lesgold, Lajoie, Brunzo, and Eggan (1990), teaching avionics troubleshooting; and (4) PASCAL ITS by Bonar, Cunningham, Beatty, & Weil (1988), a tutor on Pascal programming. With each ITS, Shute compared the student's performance to a control group. Shute's findings were threefold. First, learning rates were

⁴ Angelides, MC. and Doukidis, G.I., "Is There a Place in OR for Intelligent Tutoring Systems?" *Journal of Operations Research*, Vol.41, No.6, 1990, p. 491.

⁵ Burns H.L. & Capps, C. G., "Foundations of Intelligent Tutoring Systems: An Introduction", found in Poisson, MC. & Richardson, J.J. (ed), *Intelligent Tutoring Systems* (Lawrence Erlbaum Associates, Inc.: 1988), p.1

⁶ Sleeman, D. and Brown, J.S. "Introduction: Intelligent Tutoring Systems", found in Sleeman, D. and Brown, J.S. (ed.) *Intelligent Tutoring Systems* (Academic Press, 1982), p.2

⁷ Garcia, Anne L., *Intelligent Training Systems: Smart Tutor?*, *Bulletin of the American Society for Information Science*, August/September 1990.

⁸ Piskurich, George "The Possible Futures of Instructional Technology", *Training and Development*, March 1993, p.52

⁹ Bonar, J., Cunningham, R., and Schults, J. "An Object-Oriented Architecture for Intelligent Tutoring Systems", *Learning Research and Development Center*, University of Pittsburgh, Technical Report No. LSP-3, August 14, 1987, page 2.

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increased without any decrease in final outcomes, i.e. students were able to learn the knowledge and skills faster than from traditional pedagogical approaches. Only one-half to one-third the time was needed by the students to 'earn the material and perform equally as well as the control' group on exams. Second, the range of learning outcomes (variation in student test scores) were the same (no significant difference).

Other recent studies have shown similar results. Anderson, Boyle, et.al (1990) evaluated a geometry and an algebra tutor and found that student do seem to learn from the programs. Pre and posttests of knowledge showed statistically significant improvement in test scores. But only the algebra tutor compared the results to a control group. The geometry tutor study did not use a control group. Godin and Rao (1991) developed a prototype tutoring system for teaching an EOQ model using VP-Expert. They found it to be an effective device to provide a flexible advisory system to the student but did not detail the tests used to support their conclusion.

Despite the success stories, development and use of ITSs have been slow. A number of reasons were offered by Woolf, Soloway, et.al (1991). First, there is still a lack of tutoring-specific artificial intelligence development tools, such as shells. Second, it is not a simple task to reduce cognitive analysis to field specific applications. Third, the development cycle is lengthy from research lab to salable products.

WHY DO WE NEED AN INTELLIGENT TUTORING SYSTEM FOR BUSINESS SIMULATIONS?

Much learning in business simulations occur through the use of the scientific discovery process. The scientific process involves four types of activities (Langley, et.al, 1987): experimental data gathering; the search for important cause and effect relationships that can be described using quantitative or qualitative theorems or rules; explanations of the outcomes by formulating hypotheses; and finally, testing the hypotheses by predicting and verifying outcomes. Bergeron and Paquette (1990) have characterized this process in five main phases:

1. Free exploration to determine the general way the major variables impact the simulation.
2. Structured exploration where specific variables are systematically examined to discover more exact cause and effect relationships.
3. Hypothesis generation to clearly explain the likely impacts of key variables, usually described in the form of equations, rules or theorems.
4. Prediction formulation to test the validity of the

hypothesis.

5. Reviewing to identify new knowledge and reinforce strategies, or start new explorations.

In order to go through this process effectively it is assumed: (1) the student has the metacognitive skills to know what data to explore, how to develop and test hypotheses, and when to review and start new explorations; (2) students are not reluctant to ask questions; and (3) there are adequate opportunities to ask questions on a timely basis, i.e. when the answers to the questions are needed.

Problems arise in the learning process when students are confused and are not able to get their questions answered satisfactorily and on a timely basis. Misunderstandings may propagate and compound as execution of the simulation continues. If questions are not addressed as they occur they may be forgotten. Post-execution teaching/ tutoring is not as effective as "real-time" teaching/tutoring, i.e. when the student is executing the simulation.

These limitations are summarized in Table 1. Phases 1 & 2 are supported by allowing students to change decisions, execute the simulation, and generate new data and reports. Decision support programs like spreadsheets are also packaged with many simulations. However, the queries are limited to those contained in the simulation program and the information provided is mostly quantitative. Phases 3 & 4 and 5 are supported by market research reports and the ability, in some simulations, to do "what-if" analysis where the student can re-enter decisions to see what would have happened if different decisions were made. However, no qualitative feedback concerning the reasons for the solution or inferences relating to the solution can be obtained from the simulation program.

The essential role of an intelligent tutoring system for simulations is to help overcome these problems and improve learning effectiveness. The ITS will be able to provide the student with immediate help on-line" and support the coaching phase of an apprenticeship method of teaching. The ITS will be able to assist students in exploring the simulation data and constructing conceptual models prior to executing the simulation. This will enhance the support structure to better understand the simulation environment and process, which would not occur with passive observation. The ITS will not tell students what decisions to make but will intervene constructively when students are having trouble making decisions, performing, or when students simply have questions or need guidance. The anxiety and frustration of students so commonly reported in the initial phases of simulation

TABLE 1

EVALUATION OF SIMULATION DESIGN BY PHRASE
IN THE SCIENTIFIC DISCOVERY PROCESS

Phases	Supporting Functions	Limitations
1 & 2 Free & Structured Explorations	-selection -data & report generation -graphical presentations -spreadsheet analysis	-limited queries & processing -rigid display of data -informative mostly quantitative
3 & 4 Hypothesis & Predictions	-market research reports -what-if analysis	-no qualitative computer feedback
5 Reviewing	-historical reports -replay of simulation	-no qualitative computer feedback

THE DESIGN OF AN ITS-BASED SIMULATION

User Interface

In a conventional PC-based business simulation the user goes through the following fundamental procedure: reviewing past reports, entering decisions, executing the simulation, studying the results and, perhaps, doing some data analysis using other decision support systems like a spreadsheet program. The student repeats the procedure each period of play.

With an ITS the student can interrupt the simulation at any time (by clicking an icon of a tutor) and enter into a discussion with the tutor about the simulation, which may include the following categories:

1. The objects or words on the screen, e.g. What does Menu Choice X do?; What does this word mean? What are the effects of this decision?
2. The event in progress, e.g. suppose the student is viewing past reports on a computer screen and asks: what should I do with this information? How can I interpret the information or how can it help me? What should I do next?
3. The performance of the user, e.g. How am I doing? What went wrong? How can I improve?

Category 1 above (explaining objects or words) may seem like a standard "help" routine, but an ITS can do

much more.. The ITS would respond using natural language explanations and could behave just as an instructor, i.e. by first asking the student what he/she thinks is the answer. The ITS could discuss the answer with the student and then based on the dialogue and the student's progress in the simulation, make suggestions and refer the student to other sources of information.

For categories 2 and 3 the ITS would enter into a "natural language" dialogue with the student. The responses of the ITS would be based on the pedagogical approach or teaching style embodied in the system.

The ITS may also interrupt the simulation automatically and provide the student with advice and coaching.

ITS Model

The tutoring system needs to be intelligent in three areas. One is the knowledge the system has of how to manage and operate the business simulation. Second is the understanding of the student's knowledge, both strengths and weaknesses. Third is the principles by which it helps the student learn.

Given these areas of intelligence, it is recommended the ITS be designed with three distinct modules: expert consultant, diagnostic testing, and pedagogical

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support.¹⁰ Each module may be programmed using an expert system shell or artificial intelligence (AI) development tool with the appropriate domain knowledge.

The *expert consultant* module contains the domain knowledge pertaining to the use and management of the business simulation. The consultant module must contain all the knowledge & skills necessary to manage effectively a business simulation.

The *diagnostic testing module* evaluates how well the student is doing and what the student knows. The purpose of the module is to: (1) determine the differences between the student and expert decision-making; and (2) identify the types of knowledge the student needs to learn. This determination is based on the types of questions the student asks the ITS and on how the student responds to questions asked by the ITS to the student.

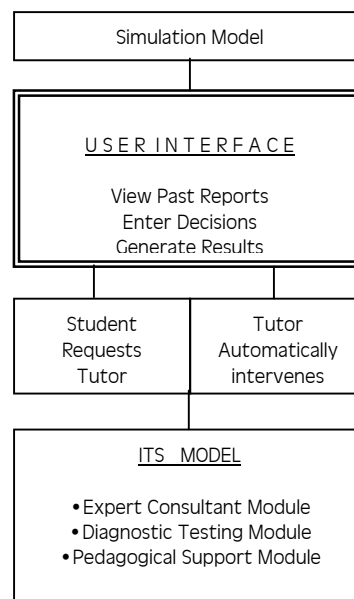
The *pedagogical support* module identifies which deficiencies in knowledge to focus on and selects pedagogical strategies to present that knowledge. The pedagogical support module needs to determine when students need help, how to provide that help and respond to student questions.

The three modules are linked to the user interface and simulation program as shown in Figure 1. The user interface allows the student to run the simulation model by viewing past reports, entering decisions, and generating results. Based on these results the student has the option to continue playing the simulation without using the ITS or the student may request some help. The *expert consultant* module would respond to any question relating to the management of the simulation; and the *diagnostic testing* module would then assess the student's knowledge (and may respond with some additional queries to the student). This information would be accessible to the *pedagogical support* module to determine the most effective tutoring strategy.

If the student does not request tutoring help, the ITS still continues to monitor and diagnose the student's performance. The *pedagogical support module* would determine if some intervention would be appropriate based on its teaching strategy and the findings of the *diagnostic-testing module*. The decision to intervene on the student's behalf is important to minimize frustration and provide some

guidance to prevent the student from going too far off track. Early intervention, however, could hinder learning-by-doing and add to the frustration of the student. The pedagogical approach of the designer must be carefully considered with respect to intervention.

FIGURE 1
DESIGN OF ITS-BASED SIMULATION



CONCLUSIONS

It is argued Intelligent Tutoring Systems are a natural complement to computerized business simulations and could significantly enhance their pedagogical effectiveness. Considering the apprenticeship model of learning by Collins, Brown & Newman (1987), where “coaching” and “fading” are identified as important elements in the *experiential learning* process, it is critical for an instructor to be available for students while they are working with a business simulation. Owing to the many students in a typical classroom, this is not always practical. With an ITS-based simulation, the actions performed by the student while running the simulation may be monitored by the ITS. If the student is successful, the system could make relevant comments concerning the student's progress to help reinforce important concepts and motivate the student further. The system could also ask meaningful questions and, based on the student's response, point out those aspects of the student's management

¹⁰ A thorough discussion of the design elements of! ITSs may be found in Poison & Richardson, (eds.) Foundations of Intelligent Tutoring Systems, Hillsdale, N.J.: Lawrence Erlbaum Associates, Inc., 1988.

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strategy that are most valuable to successful business performance. If the student is not doing well, the ITS could raise relevant questions to help the student understand the reasons for the low outcomes and offer some suggestions.

The advance in computer technology has made the development and use of intelligent tutoring systems economically feasible. Expert system shells and AI software development tools are commercially available at reasonable prices. It is expected that AI applications like intelligent tutoring systems will become major pedagogical tools by the 21st century (Piskurich, 1993). The time is now for designers of business simulations to leap into the future of instructional technology and consider the use of intelligent tutoring systems.

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