

## ITS: Training with Intelligence

*Tutor-controlled, one-on-one instruction is one of the most powerful and widely used methods for imparting learning. It offers unparalleled pedagogical flexibility and achieves verifiable learning outcomes—two key factors that make it superior to most offline and online instructional methodologies. Intelligent Tutoring Systems (ITS) are an attempt to leverage some of the key strengths of tutor-controlled learning in a computer-based environment. This article presents an overview of ITS, their components, advantages, and limitations.*

As business corporations stretch their training budgets to maximize employee learning for competitive advantage, the efficacy of computer-based training methodologies has come under the scanner. The ability of current learning technologies to improve employee performance is increasingly being questioned by training managers. At the heart of the debate is a key question: can current learning technologies empower employees with the knowledge needed to deal effectively with real-world business situations?

The consensus seems to be that most computer-based training technologies merely introduce facts and concepts to learners and then test factual recall of information using traditional question-and-answer methods. Most training managers would doubt whether such methods actually help employees tackle complex problems in different real-life scenarios. Today's widely deployed methodologies appear to be far too entrenched in traditional pedagogical approaches to contribute significantly to creating knowledge-based experts at the workplace.

The debate about such training systems raises several questions. What skills do learners develop through learning programs, and how well are they equipped to apply the learning to solve problems at the workplace? What assumptions can be made about the levels of knowledge acquired? Can learners be adequately tested on the depth and breadth of the concept being imparted? Is it at all possible to demonstrate that learners have achieved the levels required to develop expertise in the requisite subject area? Questions abound, but the answers do not often sound convincing. Has the time come for Intelligent Tutoring Systems?

### What are Intelligent Tutoring Systems?

Despite significant advances in instructional methodologies, it is widely believed that traditional one-on-one tutoring that takes place in classrooms across the world is still, perhaps, the most effective instructional methodology. Human tutors in controlled environments can provide personalized assistance to learners, correct their misconceptions, evaluate their assumptions, test their conceptual knowledge, and the application of received knowledge in practice, and provide feedback to help create knowledge experts. The high degree of flexibility that human tutors display while imparting knowledge has few parallels in the world of computer-based technologies, barring, perhaps, one—Intelligent Tutoring Systems (ITS).

ITS attempt to replicate one-on-one tutoring by encoding the subject-matter expertise of a human tutor within a software system to provide intelligent instruction. The biggest benefit of ITS is that, like human tutors, they can provide personalized, one-on-one instruction to learners. ITS enable the learners to imbibe difficult concepts and skills and then help them practice their skills by assigning specific tasks within highly interactive learning environments. Moreover, ITS can also address the learners' queries and doubts and provide a highly individualized path of instruction, based on the ability of the learners they attempt to educate. Unlike most other computer-based training technologies, ITS can customize their instructional strategies to facilitate deep levels of reasoning among learners through hints, examples, demonstrations, and feedback.

# Components of an Intelligent Tutoring System

Although there are several types of ITS in the market today, the primary structure of most systems consists of four components: the Expert Model, the Student Model, the Instructor Model, and the Communication Model.

- **The Expert Model**

The expert model contains all the subject-matter knowledge and problem-solving ability of an expert tutor. Using this vast body of knowledge, an Intelligent Tutoring System can compare the learner's actions and selections with that of an expert to evaluate the knowledge levels and the deficient areas of the learner. The expert model contains the best answers to problems and questions as well as the intermediate steps that lead to the resolution of a particular problem. The correct approaches to solving problems are embedded within the expert model to teach the learner at appropriate junctures in the learning program.

- **The Student Model**

The student model represents the student's current state of knowledge, which includes both the student's capabilities and the misconceptions they may have on a given subject. Based on this information, ITS can track the learner's problems, identify the causes, suggest remedial measures, and provide individualized instruction to the student. The student model is used to evaluate the student's knowledge in a given area and to draw conclusions about the student's reasoning process. In addition to containing data about the student's understanding of the subject, a student model also includes other general information about the student that is relevant to the learning process.

- **The Instructor Model**

The instructor model encodes instructional methods that are appropriate for the target domain and the learner. Based on the model's knowledge of a student's skill levels, strengths, weaknesses, and misconceptions, it can select the instructional intervention that is most suited to the purpose of instruction at any time. These interventions may be in the form of explanations, hints, and feedback. The model can also enable the students to reason on their own by posing relevant questions and by providing appropriate hints to spur the learners' actions. The instructor model possesses the flexibility to impart learning, based on the speed of the student's learning curve. For example, it can circumvent the normal learning process to provide complex problems to quick learners very early in the learning program. At appropriate times, the instructor model may also choose topics, simulations, and examples to improve the user's understanding of the subject.

- **Communication Model**

The communication model is closely connected to the other three models. It enables the student to manipulate variables in the learning environment and observe the results to understand the processes, causes, or procedures involved.

The communication model regulates the flow of communication in and out of the system. It connects the system's internal representation of concepts with an interface that can be understood by the student. It effectively controls the interactions with the learner through appropriate interfaces like dialog boxes and screen shots. Using the communication model, the student can experiment and construct relevant hypotheses regarding the subject.

## Benefits of ITS

- **Micro-tutoring**

Micro-tutoring refers to the ability of ITS to provide highly detailed feedback about problem solving. It breaks down the problem-solving process into discrete modular steps and displays step-by-step reasoning.

Micro-tutoring helps remove learners' misconceptions by helping them diagnose errors in problem solving. It also tracks the learning process rigorously and establishes the knowledge levels of students at every stage.

- **Tutor-Controlled Process of Learning**

Since an Intelligent Tutoring System controls the process of learning from start to finish, it can track what the student learns at every stage, the difficulties they face and their misconceptions. Based on this information, it can decide the kind of support the student needs to master the topic being learnt. It can also determine the pace of learning according to the profile of the learner and set varying levels of complexity to help all learners achieve the desired learning objectives.

- **The Error-Trigger Method of Coaching**

A powerful feature that most ITS share is the ability to use errors made by students as opportunities for instructional intervention. Coaching sessions are typically triggered by the mistakes made by the student during the learning process. This enables ITS to correct the learners' misconceptions or errors at the outset, leading to greater retention of learning. By providing rich feedback at such opportune moments in the learning process, ITS maximize learning effectiveness.

## Limitations of ITS

- **Limitations in Learning Outcomes**

The most significant limitation of ITS is that they can only be developed for select topics. For ITS to be effective, complete mastery of the subject matter is required, along with adequate knowledge of the students' misconceptions. This makes it difficult to design ITS for complex subjects or topics.

The success of ITS have been largely in areas where learners are required to master elementary procedural skills like solving short problems in mathematics and physics.

- **Limited Teaching and Pedagogical Expertise**

The other important limitation of ITS is that their pedagogical expertise is restricted to an effective but limited, drill-and-practice style of teaching. Unlike human tutors, they lack the flexibility to adopt different teaching methods when appropriate and to permit students to use different learning styles.

The limitations notwithstanding, ITS present a powerful alternative to existing computer-based learning technologies. ITS hold enormous potential for learning in the future, and the rapid development of artificial

intelligence and cognitive sciences will enable ITS to overcome their shortcomings and extend their capabilities to a much wider realm.

For organizations that invest heavily in training and wish to drive competitive advantage through employees powered by knowledge, Intelligent Tutoring Systems can deliver learning solutions that are far more comprehensive and tangible than other learning technologies that exist today.