

The Impact of Artificial Intelligence on Training

Artificial intelligence is moving from the laboratory into the world of applied training. Intelligent computer-assisted instruction (ICAI) is an exciting new addition to the growing list of educational technologies, and trainers will be critical to its development for many important commercial applications.

By LEE A. GLADWIN

After 12 years with Training Technologies, Inc., you have witnessed and coped with several revolutions in educational technology: programmed instruction, computer-based learning (CBL) and videodisc creations. Just when you thought it was safe to venture back into the classroom, you learn that your company has entered into a contract with Megacorp to produce an intelligent tutor for training technicians in troubleshooting the SUPRA-7 weapons system. Armed with only a minimal knowledge of computers, gained through playing video games on your child's computer, you attend the get-acquainted session. You have some questions.

What is artificial intelligence (AI)?

According to Herbert A. Simon, a pioneer in the study of artificial intelligence, "Artificial intelligence is the exhibition of behavior by computers which would be called intelligent if it were exhibited by human beings." In earlier phases of AI, cognitive scientists were concerned with discovering how experts represent, organize, store, access and apply knowledge to solving problems in physics, algebra, logic, cryptarithmetics and chess. The object was to develop theories about how experts solve problems in these domains and to test the theories by writing computer programs for solving the problems at a level of

expertise equal or superior to that of the expert.

In recent years, artificial intelligence moved from the academic laboratory into commercial applications, creating demand for expert systems that perform complex tasks as well as a human expert. Several systems already exist. From a set of symptoms and test results, the MYCIN program can diagnose bacterial blood infections and recommend treatment plans. Given a chemical formula and spectrogram, the DEN-DRAL program can infer the molecular structure of an earth sample in the course of locating valuable oil deposits.

What is intelligent computer-assisted instruction (ICAI)?

ICAI is an extension of computer-assisted instruction (CAI). Both are concerned with representing subject matter, anticipating wrong responses and correcting misconceptions. In traditional frame-oriented CAI, the student is branched through a lesson depending on his or her responses to questions. The sequence of the text, questions and feedback are all predetermined by the courseware author.

ICAI presses beyond the limits of frame-oriented CAI to provide what leading ICAI expert John Seely Brown of Xerox calls "a reactive environment in which the student is actively engaged with the instructional systems, and his interests and misunderstandings drive the tutorial dialogue." A fully developed system will combine the following characteristics:

- the content, skills and heuristic knowledge of the expert;

- instructional methods and content of explanations;
- tutoring rules (when to intervene and what to say);
- knowledge about learning; and
- sophisticated computer-generated graphics capabilities.

As Brown observes, "You have to know it [concepts, skills, rules] really well to teach it to a computer." In addition, an intelligent computer-assisted instructional system has a natural language interface; trainees can enter questions and responses to computer-generated questions in their own words. When fully operational, the ICAI system acts as a tutor by generating problems, comparing trainee responses (lists of concepts and skills) with those of the "expert" to that problem, diagnosing weaknesses, associating explanations and examples with errors, deciding whether or not to intervene, and providing corrective feedback.

ICAI often is used with simulation or game formats to teach procedural knowledge and troubleshooting skills. SOPHIE III was developed by John S. Brown and Richard Burton to train technicians in the repair of electronic circuits. SOPHIE III generates a graphic circuit with a defective block. The system demonstrates and explains its strategy for finding the block, then asks the trainee to predict the outcome of the next measurement. The trainee is given an opportunity to find the simulated fault through additional measurements, hypotheses and part replacements. The program detects misconceptions and provides feedback, as in the following sample dialogue

Trainee: Could Q1 or Q2 be shorted?

Lee A. Gladwin develops and writes computer-based training materials for the University Research Corporation. He is based in Winchester, Va.

Computer: I can only handle one question, hypothesis, etc., at a time. The fact that you say "OR" indicates that you may be trying to express two concepts in the same sentence. Maybe you can break your statement into two or more simple ones."

SOPHIE III answers questions, diagnoses underlying misconceptions and provides leads for further questions.

Which areas of training will be affected?

Highly structured and rule-oriented fields are most likely to be affected by ICAI. Intelligent tutors are used to train teachers in the diagnosis of students' incorrect answers to computer-generated math problems (BUGGY). Other tutors critique student programs written in LISP, PASCAL and TURTLE. Xerox and the Army Research Institute are developing a tutor for troubleshooting the Xerox 9600 copier. STEAMER applies graphics to a mathematical model of a steam plant for teaching trainees to

troubleshoot plant malfunctions and the reasoning for procedures.

ICAI is simply one more option. It can be used with existing technologies, but is not a replacement for any of them. Due to a shortage of "knowledge engineers," trainers are being asked to employ their considerable task analysis skills in extracting and formalizing expert knowledge for programming ICAI systems. Trainers are helping to develop the expert and instructional models and realistic problem sets on which these systems are based.

How can I prepare for ICAI?

Trainers already possess the essential knowledge of instructional design, methodology and task analysis. Previous experience with computers and computer-based learning is an advantage. General knowledge of artificial intelligence and ICAI is also necessary and may be gained by reading P.H. Winston's *Artificial Intelligence* (Reading,

Mass.: Addison-Wesley, 1977) and D. Sleeman & J.S. Brown (eds.), *Intelligent Tutoring Systems* (N.Y.: Academic Press, 1982).

The Army Research Institute offers informal, in-house training for its trainers. At the Xerox Training Center in Leesburg, Va., trainers work with AI specialists, read books and practice InterLISP programming on the Xerox 822 microcomputer. According to Xerox trainer Dave Davis, trainers are helpful, enthusiastic participants in this latest revolution in educational technology.

ICAI is an exciting new technology which will soon emerge from the laboratory and find many commercial applications. To be successful, ICAI systems will require the combined talents of the cognitive scientist and the trainer to create an instructionally effective, realistic training environment.



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For more information write: **Dennis Bauer**, Program Coordinator Industrial Occupations; Waukesha County Technical Institute • 800 Main Street • Pewaukee, Wisconsin 53072

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