Chapter XIII
Intelligent Tutoring Systems for Distributed Learning

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ABSTRACT
This chapter provides information on how to design intelligent tutoring systems for distributed learning to cater to individual learner needs and styles. It argues that intelligent tutoring systems must use the expertise that tutors use in a one-to-one teaching situation to build intelligent tutoring systems for distributed learning. Also, the appropriate psychological and educational theories must be used to build the domain module, student model, and pedagogical module. The components of intelligent tutoring systems are described, and the author makes the case that to build effective intelligent tutoring systems, a multidisciplinary team should be involved. Finally, the author identifies trends that are influencing the development of intelligent tutoring systems and suggests areas for future research and development.

INTRODUCTION
According to a recent panel (Corbett, Anderson, Graesser, Koedinger, & VanLehn, 1999), the current generation of intelligent tutoring systems is only half as effective as human tutors, and we need to develop tutoring systems that are as effective as human tutors. We need to study human tutors when they provide one-to-one instruction in distributed-learning systems and use the expertise to build intelligent tutoring systems. Existing distributed-learning systems are designed to instruct students based on information already stored in memory. The systems do not adapt to the needs of the learner by diagnosing, in minute detail, the sources of errors and by providing specific instruction to overcome the errors. Distributed-learning systems need to form a model of the learner and provide instruction similar to a tutor in a one-to-one interaction mode. Bloom (1984) described the two-sigma problem, which suggests that learners who are given one-to-one instruction performed two standard deviations higher when compared to learners who received face-to-face group instruction; however, providing one-to-one attention using a human tutor could be expensive...
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and time consuming in distributed-learning systems. As a result, distributed-learning systems need to develop and use intelligent tutoring systems so that the human tutor expertise is built into the computer system to provide the one-to-one tutoring to students. This is critical, because in distributed-learning systems, students could be in any location and may not have access to human tutors for one-to-one instruction.

The intelligent tutoring systems can conduct learner analysis based on initial interaction with the learner; adapt the instruction to meet the student learning style; monitor the learner’s progress, providing declarative knowledge when required; decide on the best way to present the next problem or instructional sequence (Heffernan, 1998); diagnose problems and provide corrective feedback; and oversee the successful completion of the learning process.

This chapter provides information on the design of an intelligent tutoring system for distributed learning to meet an individual learner’s needs and style. It describes the details of the components of an intelligent tutoring system and suggests trends and future research required in the area of intelligent tutoring systems for distributed learning.

BACKGROUND

Before the details of intelligent tutoring systems are covered, it is important to discuss intelligent agents, because an intelligent tutoring system is considered to be an intelligent agent system. Wooldridge and Jennings (1995) defined an intelligent agent as a computer system that is capable of flexible autonomous action in order to meet its design objectives. The intelligent agent in an intelligent tutoring system performs on behalf of the tutor to help learners achieve learning outcomes and to prescribe teaching strategies based on learners’ profiles in the student model and content in the domain module. As the agent interacts with the learner, it gains more experience by learning about the learner. The expertise in the intelligent tutoring system intelligent agent should allow the agent to help learners achieve the learning outcome without human intervention. The intelligent agent should anticipate learners’ responses and respond immediately to take corrective action or to present the next learning intervention based on learners’ characteristics and styles to maximize learning benefits. In other words, the intelligent agent should form dynamic profiles of the learner and work ahead of the learner by guiding the learner in what to do next in the learning process. The intelligent agent system should behave like an expert tutor by interacting with the different components in the intelligent tutoring system to assemble the expertise required to help learners achieve the learning outcome.

An intelligent tutoring system is one type of expert system (Sowa, 1984). Boose (1986) defined an expert system as a knowledge-based reasoning system that captures and replicates the expertise of human experts. Kearsley (1987) defined an intelligent tutoring system as application of artificial intelligence techniques to teach students. Sleeman and Brown (1982) defined an intelligent tutoring system as a program that uses artificial intelligence techniques for representing knowledge and carrying on an interaction with a student. According to Sleeman and Brown (1982), an intelligent tutoring system must have its own problem-solving expertise, its own diagnostic or student modeling capabilities, and its own explanatory capabilities. It must know when to interpret a student’s problem-solving activity, what to say, and how best to say it. Hence, an intelligent tutoring system closely resembles the process when a student and teacher interact in a one-to-one situation (Tennyson & Park, 1987).

In distributed learning, students can be in any location to take courses, as long as they have access to communication technology with which to access the course. Distributed learning could be either synchronous or asynchronous. In