Using Intelligent Tutoring Technologies to Enhance Online Learning Environments

Kausalai Kay Wijekumar
The Pennsylvania State University, Beaver, USA

INTRODUCTION

Online and distance learning environments have changed dramatically over the last 20 years and are now sophisticated interactive learning environments. However, much more improvement is possible, and some of that improvement might come from mining some of the technologies developed as part of intelligent tutoring systems. Intelligent tutoring systems combine the best of human tutoring by capturing one on one tutoring interactions between a teacher and student on all topics for a learning module and converting them to a computerized version. The computerized version is designed to gauge the understanding of the student and adapt the instruction, modeling, hints, interactions, and activities to particular students. The systems are usually designed to assess the student's learning continuously and scaffold the learning of the student. Ideally, these interactions will mimic human tutoring that has been shown to significantly improve learning beyond large group instruction.

Intelligent tutoring systems have developed ways of customizing tutoring interactions to support many different types of learners, provide immediate assessment of student performance, and useful feedback that guides a learner to their learning goal in an effective and efficient manner. This paper describes some of the analysis, design, and delivery techniques used in intelligent tutoring technologies that have the potential to enhance distance learning environments.

Key developments in the distance learning environments cluster around achieving goals such as interactivity, and active and collaborative learning. This article also addresses how intelligent tutoring systems can improve the learning outcomes of distance learning environments by incorporating the active and collaborative learning strategies.

BACKGROUND

The first intelligent tutoring systems were developed in the 1990s, building on research combining the disciplines of user modeling and effective tutoring strategies (Corbett, Koedinger, Anderson, 1997). These early intelligent tutoring environments "adopted the human tutor as their educational model and sought to apply artificial intelligence techniques to realize this model in "intelligent" computer- based instruction." (Corbett et al., 1997). Human tutors have been shown to be most effective and efficient in improving learning (Cohen, Kulik, and Kulik, 1982) and that fact remains true even today (Corbett et al., 1997, Meyer and Wijekumar, 2007). Thus mimicking human tutors using computers is a worthwhile approach to extend to distance learning environments (Meyer, Middlemiss, Theodorou, Brezinski, McDougall & Bartlett 2002). Currently, intelligent tutoring systems include the research on the learning cycle of interactivity, assessment, and feedback to help student achieve their learning goals using computer tools (Meyer and Wijekumar, 2007).

The definition of intelligent tutoring technologies combines the processes of tutoring and intelligence. First, tutoring requires creating computer systems that can imitate what human tutors accomplish with learners. Specifically, the human tutors model how to solve the problem or apply their learning. The human tutors provide activities for the learner to use the skills, observe the student's performance on the practice tasks, scaffold and guide the learner using hints and prompts, assess student learning, and provide feedback. Therefore, the tutoring component of intelligent tutoring technologies should attempt to mimic the ideal human tutors. Second, the intelligence in the computer systems are designed to "learn" from their interactions. Just as human tutors learn how to adapt to different types of learners

over a period of time, it is important for the computer to save the tutor's interactions with learners and use that information to create new interaction pathways for computer-learner interactions.

Even though intelligent tutoring systems is the term used in this chapter, there are a few other terms that have been used in the past to describe the umbrella of computer tools that contain some or all of these concepts. Computer tutors have been referred to as cognitive tutors (Anderson, Koedinger, 2000), automated tutors (Anderson, Akwarecki, 1986), model-tracing tutors (Corbett, Koedinger, and Anderson, 1997), and interactive learning environments (Aleven, Stahl, Schworm, Fischer, Wallace, 2003).

The development of intelligent tutoring environments is a multi-phased process. The development process includes an extensive cognitive task analysis of human tutoring interaction sessions followed by the crafting of tutoring scenarios based on that cognitive task analysis. A cognitive task analysis is also multi-phased, consisting of observations and recording of tutor-tutee dialogues of tutoring sessions for each concept to be learned. The analysis process documents all of the following: the goals of the learning session, the sequence of steps to achieve the learning, the challenges that the student encounters, and the tutor's approach in adapting the instruction to the student's learning difficulties. Documenting all these interactions and processes is fundamental to capturing the tutoring/learning interactions so that they can be programmed into a computerized tutoring environment.

The idea of building Intelligence into learning environments has its origins in the artificial intelligence terminology coined by Minsky in the 1980s when researchers envisioned computers solving problems in similar ways to how humans solve problems (Minsky, 1982). These intelligent tutoring technologies are still evolving. Some current technologies come close to the goal of artificial intelligence. For example, approximations of intelligent technologies include the use of rules to define interactions between tutors and tutees and then updating those rules based on new interactions.

One of the major roadblocks to artificial intelligence in computers has been the inability of computers to process natural language and understand the direct and indirect speech in the English language. For example, when a human being walks into a room and says, "This room is too hot." another human being may interpret that to mean that the thermostat should be turned down, or the air conditioning should be turned on. The same statement may also be made as a figure of speech implying something completely different than the room temperature. A computer would have a difficult time understanding such nuances in human interactions, and as a result programmed interactions in computers often fall short of human-like behaviors.

Progress is being made with new computer technologies. Recent advances in natural language processing and database technologies make it possible to use the term "intelligence" to describe some tutoring environments. Latent semantic indexing is one approach to comparing large corpora of texts for similarity and is used in scoring of essays and also used in comparing writing samples of students against ideal responses (Zhang, Berry and Raghavan, 2001). There are also numerous text parsing technologies available on the market today that will allow better interpretation of student natural language interactions in on-line environments (ApplePie 2008).

By using the latest generation of intelligent technologies, it is now possible to approximate intelligent tutoring environments in web-based learning modules in distance learning technologies. Regardless of how intelligent the system is, the basic development process of analyzing good tutoring practices, observing and recording effective tutor-tutee interactions, and assessment and feedback loops is needed to significantly improve the current distance learning technologies. The next section describes the design processes used in developing intelligent tutoring systems and shows how these processes can be applied to web-based course development.

DESIGNING INTELLIGENT TUTORING SYSTEMS

The design approach described in this article combines research by Anderson et al. (1995) in cognitive tutor development and the Meyer and Wijekumar (2007) approach to designing the Intelligent Tutoring System for the Structure Strategy (ITSS©) (ITSS 2008). The cognitive tutor was created in the 1990s to teach Algebra for middle and high school students and ITSS was designed in 2001 to help improve reading comprehension by using the structure strategy. The cognitive tutor was designed as a stand-alone computer application and ITSS is built on a web-based platform. Both use