White Paper on Intelligent Tutoring System (ITS) Requirements for SCORM® 2.0

Submitted by Elizabeth Biddle, Training Systems & Services, The Boeing Company

Dated September 3, 2008

Abstract

This white paper advocates the need for requirements for implementing an intelligent tutoring system (ITS) capability within a distributed learning environment via the SCORM 2 standard. Although primarily implemented within instructional research and development communities, ITSs have been developed for the purposes of tailoring instruction to the specific needs of a given student. Consequently, there is no standard or common practice for implementing an ITS. There have been implementations of ITS that leveraged the sequencing and navigation capabilities supported by SCORM 2004. The purpose of this white paper is to identify interest in the distributed learning community for intelligent tutoring systems. This paper recommends that the ITS community at large should contribute to the development of these capabilities should there be enough interest in the LETSI community for SCORM 2 to address the needs of ITSs.

I. Problem Definition

The problem addressed by this paper is to identify a need capabilities that enable the implementation of an ITS using SCORM 2.0. First, it is necessary to define the concept of an ITS. ITSs are computer-based instructional applications that automatically assess and diagnose student performance, provide instructional feedback, and adapt sequence of instruction to provide the student with an individualized training experience. Most ITSs are comprised of the following components:

- Expert model – representation of an expert's problem-solving skill in a machine-executable form
- Student model – real-time model of student mastery of the expert's problem-solving skills
- Instructor model – instructional strategy based on comparison of expert and student model
- Practice environment – computer-based/simulation-based learning environment in which student can demonstrate and practice his/her skills

It is important to note that there is no standard or accepted set of guidelines for implementing an ITS. As stated later in the recommendations section, it is advised that LETSI solicit input multiple ITS stakeholders to ensure the capabilities are supportive of the variety of ITS architectures.

Now that ITS has been defined, why would the LETSI or the distributed learning community at large be interested in having SCORM 2 enable the implementation of an ITS? The answer goes back to the original mission of the Advanced Distributed Learning initiative to provide tailored training anywhere, anytime. In other words, student learning experiences will vary based upon their unique learning needs and interactions with the distributed learning environment. There have been decades of research that have studied the importance of student individual differences with respect to learning and the development of instructional methods that account for individual differences (e.g., Ackerman, 1974; Ackerman, Kanfer, & Goff, 1995;Cronbach, 1949; Emerson et. al., 1999; Gagne, 1989; Kyollen & Shute, 1989; Snow, 1989), which contributed to the concept of intelligent tutoring systems and related artificial intelligence development. However, it was Bloom's (2004) publication of a two-sigma learning improvement for one-on-one human tutoring versus traditional classroom instruction that spurred research and development (R&D) activities aimed at emulating a human instructor within a synthetic training environment. An explanation for the Bloom results is that one-on-one instruction enables an instructor to adapt his instructional style and delivery to meet the student's need based on his interaction with a student (Ong & Ramachandran, 2000). More recent research regarding adaptive learning in a computer-based learning environment (Perrin, Banks, & Dargue, 2003; Perrin, Dargue, & Banks, 2004) has provided further support to the benefits of adapting training sequencing based on student learning needs.

II. Use Cases

ITS is still a concept that is not standard within any learning community, so to state a finite set of use cases within this white paper would be short-sighted. It is recommended that if there is enough interest in the community to include ITS capabilities with SCORM 2, that input is solicited from all organizations interested in ITS development. With that said, the following provides a starting point for developing a set of use cases.

- Declarative knowledge instruction – ITSs developed for development of fundamental knowledge
- Procedural knowledge instruction – ITSs developed to build upon declarative knowledge instruction involving use of scenarios that involve the application of several chunks of declarative knowledge
    i. Discrete-event – scenarios present student with a series of decision points with the decision selected at each decision point taking the student down a different path (e.g., branching)
    ii. Continuous – implementation of a scenario using a real-time simulation

III. Stakeholders

The primary stakeholder should these capabilities be supported by SCORM 2 is the ITS vendor community. Additional stakeholders include the instructional design, courseware developer, and the LMS/LCMS vendor communities as they would be the communities involved with creating an ITS application if the concept of ITS was to become more of a standard practice. Additionally, instructors will benefit from the data available to enable precise identification of learner needs at the individual level, as well as trends over groups of students. Likewise, students will benefit by maximizing the use of their time with a learning experience that focuses on their unique needs.

IV. Proposed Solution

As there is no common/standard ITS methodology or technology, the development of a set of capabilities that SCORM 2.0 will need to provide to support ITSs should be developed in a collaborative manner by individuals and organizations currently involved with ITS development.

V. Integration and Other Technical Issues

Current SCORM 2004 sequencing and navigation logic is currently limited to shareable content objects. However, web-based content, such as communities of practice, libraries, etc., can be leveraged as potential remediation content, although the content requires validation and monitoring of changes. SCORM 2 will need to provide a means for allowing for sequencing and navigation to content other than SCOs in order to take advantage of web-based content alternatives.

VI. Existing Implementations/Prototypes

Boeing Training Systems and Services has implemented a SCORM 2004-conformant ITS that has been delivered under contract to the U.S. DoD, which leveraged the following SCORM 2004 attributes: sequencing and navigation, global learning objectives, and updating of multiple learning objectives from a single Shareable Content Object (SCO).

However, the concept of ITS itself is largely a non-standard practice as various companies have implemented ITSs using unique approaches. With respect to SCORM, there have been various prototypes implemented that employ SCORM 2004.

VII. Summary and Recommendations

ITSs provide a means of optimizing student distributed learning experiences by adapting their training experience to address their unique learner needs. The practice of implementing ITSs is largely non-standard with various approaches and definitions in use. It is recommended that LETSI obtain input from the ITS community to refine these capabilities.

VIII. Reference

Ackerman, P. (1974). *Learning and Individual Differences: An Ability/Information-Processing Framework for Skill Acquisition* (Office of Naval Research Technical Report NR 4422-543).

Ackerman, P.L., Kanfer, R., & Goff, M. (1995). Cognitive and noncognitive determinants and consequences of complex skill acquisition. *Journal of Experimental*

Psychology: Applied, 1(4). pp. 270-304.Anderson, J.R. & Reiser, B.J. (1985). The LISP tutor. *Byte*, 159-175.

Bloom, B.S. (1984). The two sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher*, Vol. 13, Nos. 4-6.

Cronbach, L.J. (1949). *Essentials of Psychological Testing: Third Edition.* New York, N.Y.: Harper & Row.

Emerson, M., Miyake, A., & Rettinger, D. (1999). Individual differences in integrating and coordinating multiple sources of information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25 (5). pp. 1300-1321.

Gagne, R.M. (1989). Some reflections on learning and individual differences. In Ackerman, P.L.; Sternberg, R.J., & Glaser, R. (eds.), *Learning and Individual Differences: Advances in Theory and Research.* New York, NY: W.H. Freeman and Company. pp. 1-12.

Kyllonen, P.C. & Shute, V. J. (1989). A taxonomy of learning skills. In, Ackerman, P., Sternberg, R., & Glaser, R. (Eds.). *Learning and Individual Differences: Advances in Theory and Research*. New York, NY: W.H. Freeman & Company. pp. 117-163.

Ong, J. & Ramachandran, S. (2002). Intelligent tutoring systems: The what and the how. *Learning Circuits*, February. Available at: http://www.learningcircuits.org/2000/feb2000/ong.htm

Perrin, B., Banks, F., & Dargue, B. (2004, December). *Student vs. software pacing of instruction: An empirical comparison of effectiveness*. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

Perrin, B., Dargue, B., & Banks, F. (2003, December). *Dynamically adapting content delivery: An effectiveness study and lessons learned*. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL

Snow, R.E. (1989). Aptitude-Treatment Interaction as a framework for research on individual differences in learning. In, Ackerman, P., Sternberg, R., & Glaser, R. (Eds.). *Learning and Individual Differences: Advances in Theory and Research*. New York, NY: W.H. Freeman & Company. pp. 13-60.