A Literature Review on:

An Exploration of

Internet Programming Technologies

for Learning

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Principles of Web Technology

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Abstract

This literature review offers a commentary on programming applications specifically in the area of emerging online technologies for learning. Included is a brief history on the growth of these instructional technologies. We explore four literature reviews that discuss intelligent tutors (used on a one-to-one basis and in a collaborative environment), and virtual reality environments. These publications show students working online successfully in a range of learning situations, where students become more active learners and exercise various choices in the process. Intelligent tutors can be designed to adapt to individual learning styles, and to other learner characteristics. Virtual reality environments offer unique immersive learning experiences. Programmers and researchers are working diligently to develop custom intelligent solutions to online learning needs. Evaluations presented show positive results to date. Obstacles still remain to development in terms of costs and other factors. Implementation and research continue.

Introduction

Internet technologies are changing our lives and our educational systems (Sheybani, & Javidi, 2004). This literature review presents an overview of four articles on the development of technologies used in online computer based education. The articles reflect continuing change as technology advances become pervasive. Theories about learning environments, and programming and hardware capabilities continue to change. People want educational opportunities that provide flexibility in terms of access, time management, and control (Hooper, & Reinartz, 2002). Education online will indeed become even more accessible, more convenient, and there will be learning environments tailored to the learner's choices (Jalobeanu, 2003). Educators will have to make the extra effort to keep online learning interesting (Porter, 2005). Researchers are working hard to meet increased programming needs.

There are at least two threads of development that lead to our current state in online instruction. One reflects the development of artificial intelligence or AI. The other area reflects instructional technology changes. A few milestones in AI include: in the 1950s, Norbert Weiner discussed feedback loops such as the way thermostats measure temperature changes and adjust their settings. He said that intelligent behavior worked in the same way, and might be simulated by computers (www.thinkquest.org, 2006). Newell, Simon, and Shaw created the first artificial intelligence program, Logic Theorist, in 1955-56 (Stottlerhenke Associates, Inc., 2006). In the 1960s, Eliza, a computer for language between people and computers, was developed, and used intelligent agents (Piramuthu, 2005).

The other area of development became apparent in the 1950s, when IBM research teams created computer assisted instructional programs for public schools. People had high expectations for educational use that were not attained. This low level of development continued though the 1960s, 1970s (the PLATO system) and the 1980s. Also in the 1980's, Papert developed the Logo programming language and children learned to develop simple programming skills (LeFrancois, 2006). By the mid 1980's, computer use in the schools had expanded to 40% of United States elementary schools and almost twice that in the high schools. By the mid 1990s, computers were integrated primarily in word processing or drill and practice exercises (Reiser, 2002). Since 1995, with the growth of expanded capabilities in multimedia, bandwidth, and programming technologies, the use of the Internet for instruction expanded and enrollments increased. By 1998, 78% of public four-year colleges and universities offered online classes (Reiser). The military, business, and educational institutions began to increase computer based online training in order to make training more accessible at lower cost. Students could learn at their convenience, and could limit training to precise information. Educators became increasingly aware of opportunities to create online learning that would offer more student autonomy and more student control, attributes of constructivist learning (Reiser). There are now over 10 million students online globally (Jalobeanu, 2003). Universities use learning management systems such as blackboard.com, WebCT, DigitalThink.com, eCollege.com, and skillsoft (Piramuthu, 2005).

Some expectations in online learning courses are: they should offer expert information, practice, guidance, experience, feedback, assessments and flexibility (Alessi, & Trollip, 2001). Beyond that, intelligent tutors are meant respond to students' individual abilities and provide more interactivity (Ong & Ramachandran, 2003). Can the learner actively explore and control the experience? Is collaborative learning taking place? Is the online learning interesting to learners? Online environments may include behavioral components (such as Skinner's operant conditioning with rewards for certain behaviors), cognitive components ("…memorization, attitudes, motivation, …reflection, and …internal processes…"), and constructivism, where students construct their own meaning (Alessi, et al., p. 19, 2001). What are the many programming issues to consider? What are advantages of these systems?

We will now explore the use of several learning systems that are changing the web-based educational process. Among these methods are: intelligent tutoring systems and virtual reality programs or simulations (LeFrancois, 2006). Both types of systems have developed applications for individualized learning experiences, but work differently. Intelligent tutoring is a process whereby students receive customized instruction or feedback from online "intelligent" computer tutors or agents that are designed to implement teaching tasks and change behaviors depending on cues, in a given area (Piramuthu, 2005) Students are provided opportunities to practice learning content in interactive ways, except that the software provides the (virtual) tutor (Ong, & Ramachandran, 2003). The learning experience is intended to be similar to one-to-one teaching, is customized to the student, and can promote an active and involved learning experience. In Virtual Reality Environments (a simulation system), the students may feel as though they have become totally immersed in an experiential learning situation, sometimes with others. These simulations provide online learning environments in which students have an opportunity for engaging, interactive training that provides experiences very similar to a real world.

Article I: "An Intelligent Tutoring System for Circuit Analysis",

by Butz, B. P., Duarte, M., and Miller, S. M. (2006).

This article begins with a brief history regarding expectations for the first computers. One school of thought was that they would mostly be used for manipulating data, and another was that computers would manipulate symbols and perform human functions such as making decisions. This latter concept formed the foundation for the area of artificial intelligence. Eventually, those in the field of artificial intelligence developed applications for use in the area of expert systems and education. One such application is the intelligent tutor system. Here the system is meant to teach almost as well as a human subject matter expert. The authors say that in the 1960's, when educational computer applications were first developed, their functionality changed from functions that aided teachers to being used directly with students in computer aided instruction (CAI). In the 1970s-80s, this system became more intelligent (used artificial intelligence) and eventually it developed into an intelligent tutoring system (ITS) for the student. Today, there are a variety of computer aided interactive applications, such as tax preparation systems. With the advances in multimedia applications, computing hardware, and bandwidth during the last ten years, there is now an opportunity to develop more advanced web intelligent tutoring systems.

They believe the challenge now faced is in the area of environmental learning design. A chart of the model is presented, based on the concept of an "instructional model" (rules) at the center, surrounded by an "expert model" (a tutor that processes feedback), "instructional environment" (an educational model for the software environment), and "student model" (student data such as learning style, knowledge base), each capable of interacting with the "instructional model" (Butz et al., pp. 216-217, 2006). The authors explain what each element does and clarify learning objectives to develop learning based equally on objectivist – constructivist theory. This focus would consider the learners as having to meet specified objectives, but would also give them some choice over the learning goals and methods.

The Interactive Multimedia Intelligent Tutoring System (IMITS) was introduced and tested on electrical engineering undergraduates in a beginning engineering class on circuitry. The system creates an imaginary corporation for which students work and for which they must solve problems that integrate content and materials presented in the class. Students interact with the corporation in a variety of ways; this includes email and job assignments, reporting to superiors, and performance of engineering design. This program, created with Macromedia Authorware, gives students a virtual circuitry lab. The software then follows a logical, detailed process of dynamically generated material presentations, hints, feedback and monitoring. The student has some choices but must, by the end, master each section (according to the tutor's objectives) to a required standard (60%), or the student will not be considered successful.

The evaluation considered two aspects, both usability and an assessment of how well the students achieved learning objectives. 114 students completed Likert scale usability questionnaires. Overall, they did consider it a valuable method for learning (mean 3.56 on a scale of 1-5). There are more detailed statistics listed for further information. In terms of reaching learning objectives, there were a variety of questions and results. They summarized, “For all differences that were statistically significant, students in the experimental group scored higher on performance measures…”. They concluded that their approach, “guided constructivism”, provides the main characteristics of a system that gives the student some control, clearly separates learning objectives to allow for expert system interventions, provides a simulated lab, and is unique.

This article provides a good background in AI and lead introduction for this literature review. It introduces some common themes in the area of intelligent tutoring development, such as: methodology, educational theory (essential in intelligent tutoring and simulations), and gives an excellent example of the type of training it can provide. It is a detailed explanation of the process and provides charts of interactivity and decision-making points for the intelligent system. The conclusion provides reason to believe that in the future we will see more intelligent tutoring, especially as it becomes more sophisticated. In terms of interactions between student and student, and student versus teacher, there are students interacting with tutors; student-student interactions took place in the real classroom.

Article II: “Intelligent Tutoring Systems for Distributed Learning” by Mohamed Ally (2005).

In this article, Ally explores the concept of intelligent tutoring systems that focus on needs of individual students with unique learning styles. Research for applications to collaborative learning would come later. He refers to research by Bloom of the “two sigma” problem in 1984 that concludes that one-to-one instruction is more effective for learners than traditional classes. Because distributed learning systems may not offer the same benefits as having an individual human tutor, but can be accessed from anywhere, the goal is to improve the software so it can offer learning results similar to one-to-one human teaching. The author describes features of a possible system in which one feature is the use of intelligent agents. In this case, the system is "…capable of flexible autonomous action…" to fulfill tasks (Ally, p.164, 2005). Learner's needs, objectives, and styles are among the factors determined by the tutors. The goal is to produce the best learning outcome through a uniquely customized experience. He references Kearsley who states that artificial intelligence is central to the design of intelligent tutoring systems. Ally refers to situations where students are working synchronously (no time delay) within the learning system but from different locations. Analyses of test scores between groups of students where one group has an online tutor and goes to lectures, and the control group only goes to lectures show statistically significant benefits to using intelligent tutors, especially for those not doing as well. The tutors, designed by teams of experts, improve their own customization with use, creating unique databases of learning strategies for students based on student learning styles. Ally advocates an emphasis on meeting this instructional goal.

The intelligent tutoring system is comprised of the following: a student, an interface module, a pedagogical module (determines teaching materials and feedback), a domain module (content information), and a student model, similar to a human tutor. Ally reiterates that the goal is active learning (a constructivist concept) that allows students to practice, to interact with peers and teachers, and to transfer learning (apply learning to other areas). In the domain area, semantic networks, logic capabilities, and more would be integrated. The student model develops a pattern that, over time, will integrate the actual student's learning style, preferences, behavior, interest, views, and knowledge base. The pedagogical model is constructed to integrate theories of the learning process. This module is modeled upon guidelines and interactions of real tutors. The interface module appearance and functionality must integrate the components in a way most conducive to learning and in the most effective format for the student Ally discusses these interactions, and the various issues of in depth.

Trends include demand for speedy product development and identification of student's weakest areas. Intelligent tutoring development requires experts from enough areas to provide authoritative knowledge. Research would improve the technology; a focus of the research should be on individual as well as distributed learning applications. The application of constructivist learning concepts should be ensured. Lastly, another feature currently missing for students is lack of emotion or affect in the tutors.

This article presented a clear explanation of an intelligent tutoring system. Ally's support for more customization for learning style is an emphasis of the article. Different subjects, reinforcements and methods work better with different students (Allessi, et al., 2001). Studies show that motivation is also one of the important differences in how students learn. Would other factors such as this be integrated? He mentions lack of affect in the tutor as one shortcoming: what are the consequences of this? This article was extremely informative and brought out issues in the design of online instruction. It confirmed that there have been learning results found similar to those in Article I.

Article III: "Collaboration and Cognitive Tutoring: Integration, Empirical Results, and Future Directions", by Harrer, A., McLaren, B., Walker, E., Bollen, L, and Sewall, J. (2005).

This article is on authoring of online tutoring software for students through the use of collaborative tools such as Cool Modes (Collaborative Open Learning and Modeling System) used with Cognitive Tutors (CTAT). The authors do not question the value of intelligent tutors on a one-to-one basis, saying this has already been demonstrated. They discuss programming development and give results of the studies in which their software was used in a collaborative environment. They make observations on areas for further development.

Cognitive Tutors is the name of the intelligent tutoring software that is based on a "guided learning by doing" philosophy (p.1). A few questions considered were: can the cognitive tutor be modified to enable functions such as chat? Are collaborative models too complex for this kind of modification? What elements define workable collaborations? The authors' goals were to obtain and evaluate data from an experimental collaborative situation to determine what the cognitive tutor should be able to do. From these conclusions, they would develop a new model of tutor to function in a collaborative environment. The authors refined a method (BND or bootstrapping novice data) to use as students in the newly created environment recorded (through a BR, behavior recorder) and created a graphical interpretation of student work ("behavior graph"). They used Cool Modes and the Cognitive

Tutor Authoring Tools for development of this tool, but have not completed the next step of integrating the information to create an intelligent tutor for a collaborative environment.

The authors discussed the tools and interfaces. The two pieces of software communicated to each other through use of a “Tutor Adapter” and a MatchMaker server. A graphic then displayed the functionality of the system. This two dimensional visualization provides them with a useful tool for further development. The authors distinguished five different aspects of the students’ work: “conceptual understanding”, “visual organization”, “task coordination”, “task coherence” and “task selection”. The behavior recorder analyzed these five elements in different ways: some by word combinations and some by courses of action. Doing analyses was challenging because of the variety of tasks (including chats). Through two experiments, the authors were able to track what they called “positive and negative” strategies. They could also follow the extent of collaboration and comprehension. They reviewed criteria for their analysis of the data in the five areas, which provided some meaningful results. In the course of working, they refined procedures, functionality of the BR, added hints, and used the graph for feedback. They stated that their method could provide student data for this purpose in less time than previously possible, and that using their graphical tool, results would be easier to comprehend.

In this study, including two experiments, the authors gathered useful data about the foundations of their AI program, the five dimensional units analyzed, and the complexity of the problem. Their Behavior Recorder will have other applications. One area they plan to focus on is analysis of action phases and their ordering. This article focused on the background, design and development of a collaborative environment for cognitive tutoring, and had a detailed emphasis on programming sequence. The authors modified their system to improve functionality and they described procedures in great detail. Because they were working for a collaborative learning model, this development and implementation, when done, would fit into a more interactive cognitive or constructivist-learning model because it would allow for student-student interactions, rather than just student-tutor interactions. Benefits of collaborative learning environments have been documented (Allessi, 2001). It would most likely be useful for a range of educational situations. The publication provided an example for how one might proceed to gather data and derive empirical results for intelligent tutor directions or software in general, including the kinds of variables, level of detail, and organization to consider. This was a step in their project development, raises useful questions, and shows the commitment and time needed.

Article IV: "VR Learning: Potential and Challenges for the Use of 3D Environments in Education and Training" by Fabrizia Mantovani (2003).

This article includes some historical treatment, and an introduction to Virtual Reality as a useful technological tool and simulation device to achieve learning objectives. Mantovani discusses what VR is (a digital three-dimensional environment with audio effects, created and experienced via technological equipment). The author makes clear that the use of this technology has been growing since the 70's until today. VR environments may be web based, but do not have to be.

There are five main kinds of VR environments. VREs (virtual reality environments) consist of learning environments in which students can seem to actually experience effects of the training.
1.) Students may use "desktop VR". This is called subjective immersion and here students wear a Dataglove or use other tools, such as a mouse, to interact in a digital or virtual world that has been created for the training. 2.) A powerful experience is called "fully immersive VR". In this case, an HMD (head mounted display) covers the user's head and gives control. The user feels present in the VRE and sees the world as three-dimensional (such as in NewtonWorld). 3.) CAVE is a variation in which room walls are used for projections of the computer created reality. The advantage of CAVE is that multiple users can be involved simultaneously. 4.) Using "telepresence", users may be involved simultaneously, except not necessarily in the same location. They (or "avatars") maneuver in the same virtual world but from different places using video and robotic equipment. 5.) Lastly, there is "augmented" VR in which 3D virtual images populate actual worlds (Mantovani, p. 214, 2003). The military uses VR in this way.

Some benefits of VR learning are: learners would have more active voices in their own learning, depending on learning characteristics; it would offer new representations of conceptual information and graphical objects and training for situations not otherwise available (some military training or space travel for example). The learner would find the process engaging. It allows for the customization of an experience to the learner's pace and needs. The training process and learning outcomes can be recorded and evaluated. Some uses for VRE's are: in the military, in medical training, in education, in science applications, in habitat design, in training for special needs learners limited in experience and travel capabilities, and more. Some challenges in the design of these environments include maintaining the learning objectives in a given training design, maintaining age appropriateness relative to learning development, and developers must work cooperatively with teachers. He says these are not technological problems; they are instructional design considerations. He mentions that the cost of development for these custom systems remains an obstacle. Mantovani reviews detailed scales by which to assess learning and uses a model called CEMDA to work out methodologies. He recommends that these methods be standardized. There should also be standardization in development of VR systems, teachers need training in utilizing VR, and there are safety concerns in using it ("simulator sickness", eye problems and more). Usability remains an issue to be solved by having all involved parties be part of the development process.

Mantovani discusses learning theory, constructivism, and instructional goals, where each student would "construct" their own meaning. VR would facilitate this kind of interactive, self-paced learning experience. He says that VR offers "exploratory learning" where students can become actively engaged in new conceptual and experiential learning. It offers an individual or group experience. There is a social value for students who share VR environments; these are important in cognitive development (LeFrancois, 2006). These are just a few of the arguments he makes for the value of VR instruction. These references to constructivism, learning theory, and social interactions show his concern for attainment of educational objectives.

The technology used here integrates motivation as a factor in learning; the examples probably did engage students. It offers the flexibility to adapt to learning styles and educational objectives and to evaluate learning experiences through responses in the simulations. VR use may present problems regarding costs and lack of standardization. These remain as obstacles to a very unique application.

Conclusions

A comparison of these four articles provides us with similarities and differences in these interactive learning environments. We do see that in all cases, students are beginning to have more control and choices in these experiences. They were offered constructivist and cognitive experiences in varying amounts. The required mastery of materials was an integrated part of working with the intelligent tutors. All articles discussed evaluation. Programming issues are complex, especially in collaborative environments with so many interactions to record and analyze. Development processes were at different stages, but all areas were moving forward. In Article I, with an intelligent tutor system as an online unit in a traditional circuitry course, statistics showed positive results compared to the control group. The goal in this environment was to be interactive on a one-to-one basis. Article II confirmed that intelligent tutors improve learning and are being designed to adapt to learning styles in one-to-one distributed environments, but lack of emotional expression is found to be a shortcoming. In Article III, the authors are in mid-development of intelligent tutors for a collaborative environment, a substantial step, and their progress illustrates one track being taken. One of the goals in VR environments (Article IV) is to increase understanding, such as learning about science in NewtonWorld or social interactions in The Sims (another collaborative model).

These different approaches are based on AI and virtual reality applications. They illustrate just a few directions for the future of instructional technologies. The two threads we mentioned at first are now interwoven. Studies show positive learning results so far. Researchers are extending the intelligent tutor model. More instruction is geared to active learners and a changing society. Learning can be extremely customized and responsive. Programming capabilities and learning theory are advancing along with our expectations for increased control and meaning in our lives. Intelligent tutors and virtual reality experiences will not replace human teachers or human interactions. Costs remain an issue (Reiser, et al., 2002). However, these systems offer learning experiences that might otherwise be unavailable. It is impossible to predict the future, but we can be sure that these technologies, and those to come, can potentially change the nature of education profoundly.

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