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ABSTRACT

A review of research in distance education indicates that results are consistent in that there is no significant difference in achievement contributable to the delivery system. This "no significant difference" perspective represents a very narrow vision of the research actually occurring in distance education. This paper attempts to examine the "no significant difference" perspective by looking at research related to three other factors: learner interaction and control, two different approaches to multiple learning styles, and utilization of intelligent agents to facilitate interaction and collaboration. The first section looks at using computer assisted instruction (CAI) to support K-12 distance education. The second section explores a classification system for learning styles that would prove useful to help interpret the research related to learning styles in education. The third section explores learning styles in one specific setting, and the fourth and final section examines the emerging technology of intelligent agents and what impact this might have on changing the paradigm of distance education. (Contains 79 references.) (Author/AEF)

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Distance Education: Looking Beyond the No significant Difference

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Abstract

A review of research in distance education indicates thatresults are consistent in that there is no significant difference in achievement contributable to the delivery system. And it is this 'no significant difference' that seems to be quoted most frequently. Thisperspective represents a very narrow vision of what research is actually occuring in the field of distance education. This paper attempts to look beyond or behind this no significant difference in achievement by examining research related to threeother factors: learner interatction and control, two different approaches to multiple learning styles and ,utilizing intelligent agents to facilitate interaction and collaboration. The approach has bee taken to not simply reviw what has been studied but to examine areas for future study that will make significant contributions to the field.

Introduction

Research in distance education has tended to follow the same trends as research with other new technologies. The first factor that is explored is related to learner outcomes. The temptation is there to try to prove that the use of new delivery systems result in higher student achievement. The multitude of media comparison studies conducted in the area of distance education have shown repeatedly that distance education is at least as effective as traditional education in regards to learner outcomes (Hanson, et. al, 1996, Russell, 1999, Saba, 2000). In fact, several studies have produced results that indicated distance education students had a higher achievement than those in traditional settings. However, a review of the literature supports a perspective of research in distance education that is examining this phenomenon from multiple approachers. This paper presents an examination of the research in distance education examining factors beyond achievement including emerging technologies, learning styles and interaction.

The first section will look at using CAI to support K-12 distance education. While CAI appears to be decreasing, it offers intriguing possibilities when explored for its distance education potential particularly in the K-12 setting. Learning styles appear frequently in the distance education literature. However, the utilization of multiple models and instruments makes interpreting and generalizing the results difficult. The second section explores a classification system for learning styles that would prove useful to help interpret the research related to learning styles in distance education. The third section explores learning styles in one specific setting. The use of Web-based instruction continues to increase but little has been studied in regards to learning styles and designing web-based instruction that supports multiple learning styles. The fourth and final section, examines the emerging technology of intelligent agents and what impact this might have on changing the paradigm of distance education.

Using CAI to Facilitate Distance Education in K-12

Since 1985, distance education has been growing as a means of teaching and learning. Distance education enables bringing knowledge to students regardless of the limitation of time and geographical location. It has been typically defined both as a synchronous mode and as an asynchronous mode. Contemporaneously, Computer-Assisted Instruction (CAI) has been evolved since 1960s. CAI is an effective intervention for improving students' achievement in different subject areas (Christmann, Badgett, & Lucking, 1997). Researchers have dedicated many efforts and money to study and improve the instructional design of CAI. However, with the rapid development of distance education, the use of CAI seems to be decreasing in popularity. It is no longer the spotlight compared to the foci on other delivery methods within distance education. Nevertheless, CAI has another chance to gain the attention of instructors and instructional designers again with the increasing use of distance education within the context of K-12.

Instructional Forms

Lauzon & Moore (1989) thought that a successful application is dependent upon understanding how the technologies can be used to enhance distance learning. Hence, it is necessary to review instructional forms prior to adopting a specific instructional design for distance education. Kowitz and Smith cited in Lauzon &Moore (1989) mentioned the three forms of instruction represent positions on two dimensions: the density of content to be learned and the styles of human interaction. Different instructional forms require different styles of learner/instructor interaction.

The first form represents learning the basics. It is characterized by instructor control of the development, design, and evaluation. The second form assumes students an active role in their education. The instructor acts as an expert and becomes more consultative with students. It is characterized by instructor control as well as learner control of field study. The third instructional form is characterized by experts seeking to improve and master their existing knowledge and performance. It is more toward learner control.

Factors Influencing Learning, Interactions, and Control in Distance Education

Vrasidas and McIsaac (1999) concluded the structure of the online transaction, class size, feedback provided to students, and students' prior experiences were the major factors to influence interactions. Baynton (1992) indicated that the factors of "control" in distance education are competence, independence, support, time flexibility, value orientation, and access to resources.

By comparing aspects of studies, we can make an assumption that we are comparing students' expectations (Vrasidas & McIsaac, 199; Baynton, 1992) and teaching behaviors (Mckenzine et al., 1998). Students' expectations are more in terms of self preferences, while teaching behaviors are more in terms of management and instructional concerns. Nevertheless, requiring and providing support and feedback are congruent.

Distance Education in K-12

Currently, most of the attention given distance learning programs in K-12 schools is focused on synchronous modes of instruction (Barker & Dickson, 1996). Schools are using distance education technologies to help them offer both elective and required courses for which a certified teacher is not available or in situations where low student enrollments do not qualify a full-time teacher being hired. Barker and Dickson (1996) indicated that the most common technologies used in distance education programs in K-12 have been satellite-delivered instruction, cable television, and computer audiographics. Even so, Barker and Dickson also indicated that the use of the Internet and the Web to assist distance education has been emerging.

Characteristics of CAI

It is essential that CAI applications be examined in order to seek consistency with instructional forms as well as interaction styles and controls mentioned above. Thesaurus of ERIC descriptors cited in Fourie (1999) defines that CAI stands for an interactive instructional technique in which a computer is used to present instructional material. CAI can monitor learning as well as present corresponding instructional material to what individual learner needs. Lockard, Abrams, and Many (1997) described the nature of CAI as the following:

> Computer-assisted instruction (CAI) is the most common term for the interaction of a learner with a computer in a direct instructional role. CAI software provides instruction in some particular content in any of a variety of formats, with or even without any involvement of a human teacher. (p. 190)

The major characteristics of CAI are interaction, flexibility, and meeting student needs (Lockard, Abrams, & Many, 1997). CAI engages learners interacting directly and continually with computers. Learners take active roles instead of passive roles in their learning processes. It provides feedback to learners as well. Its flexibility allows teachers involving in teaching both higher-order problem-solving and simple cognitive learning. Furthermore, it can response to different needs due to different levels of competencies that learners hold. The advantages and disadvantages of CAI in terms of distance education are discussed in the following.

Advantages. The advantages of CAI are (Fourie, 1999; Lockard, Abrams, & Many, 1997; Luzon & Moore, 1989; Daniel, 1999):

1. Interaction: CAI engages learners interacting directly and continually with computers.
2. Immediate feedback: CAI is capable of providing immediate feedback to learners.
3. Self-pacing: Learners can learn at their own paces with CAI.
4. Visualized effects and sound: Integrated effects can impress learners to keep their retention and extend the duration of their learning.
5. Branching for different interests or difficulties: Learners can go through the order depending on their own learning styles and entry levels.

6. Providing sufficient drill, practice, simulations, and games: CAI provides plenty of opportunities to learners to do drill, practice skills, simulate problems, and have fun while learning.
7. Independent tutorial: Learners can go through the tutorial when they need.
8. Allowing a large number of learners: CAI applications can be duplicated and distributed easily.
9. Time flexibility: Learners can use CAI at their own convenience.

Disadvantages. The disadvantages of CAI includes ((Fourie, 1999; Lockard, Abrams, & Many, 1997; Luzon & Moore, 1989; Joseph, 1999):

1. Cost to develop: It is expensive to develop a new CAI application and takes much time and many efforts of people involved.
2. Computer platforms: If CAI only used for distance education by distributed learning, different computer platforms that learners have should be considered and can be a problem.
3. No standards to apply applications: There is no standard for what CAI application to apply for courses.
4. Requiring computer skills: Certain computer skills are needed while working within an CAI application.
5. Lack of synchronic oral communication.
6. Eyestrain: It is easy to get eyestrain after a long period of watching the computer screens.

However, Olcott (1997) argued that distance education does not necessarily save money in the short term if we view distance education from a value-added perspective.

Discussion and Conclusion

Olcott (1997) stated the shift to competency-based assessment models that certify learning through mastery of specified skill competencies rather than learning based on credit hours and seat time has impacted K-12 school restructuring initiatives. The shift may use CAI applications to achieve its goals since CAI applications can provide students with what individual needs and enhance learning. CAI can work for K-12 students in the diverse subject areas and further in the distance education context.

CAI is well known for its ability to address the independence of learners. This aspect relates well to how distance education works for most participants. Through distance education, K-12 schools can obtain collaborative and cooperative teaching and learning. CAI has the potential to enrich and facilitate distance education for K-12 schools. With the help of CAI, the use of distance education in K-12 could be extended to every single possible geographical and content area.

CAI is congruent with how distance education works. Traditional distance education programs of the past 10 years operate mostly in the synchronous mode; however, increasingly, programs are being offered in the asynchronous mode especially because of the rapid development of the Internet and the World Wide Web (Baker & Dickson, 1996). Garrison's opinion (1986) cited in Lauzon and Moore's observation (1989) indicated that the new generation of delivery system for distance education should be capable of both asynchronous group and individualized instruction and integrate the communications network with computer-based instruction. In other words, CAI combining with the Internet and the World Wide Web is the ideal application for distance education. It is evidenced that Web browsers are powerful programs which can integrate various types of media. Web browsers provide an inexpensive and widely available application that can combine text, graphics, audio, video, data, and programming within the same software program (Daneil, 1999). Consequently, CAI on the Web does not need to address the problem caused by the different platforms of computers

It is easy to update or upgrade CAI applications via the Internet so as to save cost and time from publishing and distribution. While learning with CAI, learners will have easy access and jump to different resources due to the connections with the Internet and the context of the World Wide Web. Learners also can acquire immediate use of e-mail, chat-room, and even Internet phone to have online communications with others. Developing CAI for the Web also facilitate collaboration by geographically dispersed institutions (Daneil, 1999). This will increase collaboration and cooperation between schools.

In sum, CAI applications for distance education for K-12 students should integrate with the Internet and the Web. The Internet provides synchronous settings as well as asynchronous. The implements and potentials of CAI on the Web in distance education for K-12 need to be studied by researchers, instructors, and designers much farther in the future.

The Influence of Learning Styles in Distance Education

Research studies in distance education have measured learning styles using different instruments and have classified these styles according to various schema. Most of these studies used subjects that were either not representative of the population or were samplings of convenience. These conditions complicate the comparisons of the resulting data. In order to compare learning styles across these research studies, the learning style instruments and classifications need to be related to general models. Claxton & Murrell (1987) have classified learning style instruments into three broad learning style models: 1) instructional preference, 2) social interaction, and 3) information processing.

Instructional preference models address motivation and persistence of the learner. Social interaction models are learning style models that address the learner's need for an interchange of ideas or knowledge with one or more people concerning the learning material. Information processing model address the influence of the structure of the instruction, an individual's self-concept as a learner, distinct personal goals, and expectations of success or failure on the amount of information learned. Learning styles are the combination of the developmental, cognitive, and affective factors that influence the way in which we process and perceive information.

Instructional Preference Models

Instructional preference models are learning style models that are associated with environmental and emotional preferences. Emotional preferences that address motivation, persistence, and structure have been extensively studied in distance education. Research has shown that knowledge acquired through activities that motivate the individual is learned more deeply than rote memorization (Cognition and Technology Group at Vanderbilt, 1993). Persistence, which is a function of motivation, is the extent to which an individual continues to do an activity.

In distance education, many research studies have investigated the persistence of learners either within a course or within a program. These studies have examined previous educational level, age, gender (Coggins, 1988; Powell, Conway, & Ross, 1994; and Richards & Ridley, 1997), employment, illness, family problems (Coggins, 1988; Gibson, 1996; and Powell et.al, 1994), support programs, tutors, and quality of instructional material (Powell et. al., 1994). Many different schemes have been used to provide an explanation or prediction of attrition, but the single point of agreement is that attrition is multivariate in nature (Gibson & Graff, 1992). When examining how learning styles affect persistence, we must look at emotional elements that relate to motivation. Motivation, whether intrinsic or extrinsic, helps to drive the student to learn a particular piece of information. With intrinsic motivation, a learner is driven internally by interest and curiosity and learning that piece of information is important to the learner himself. A learner that is extrinsically motivated is driven to learn a particular piece of information by a requirement imposed by some outside force. The importance of that requirement to the learner will determine that amount of drive to learn the information.

Another factor that is common in a number of distance education persistence studies pertains to the learner's perception of his ability to succeed in the educational setting (Gibson, 1996; and Powell et. al., 1994). A learner's academic self-concept is important as a predisposing characteristic in the learner's ability to complete a distance education program (Coggins, 1988). The confidence a learner has in his ability to succeed in a course could affect the learner's motivation

Coggins also stated that major motivational factors influencing a learner's persistence in a distance education course are goal-clarity and course relevance. These motivational factors can be intrinsic or extrinsic factors and are significant influences on distance education persistence. The students who intend to earn a degree and/or who were taking a distance course that was relevant to their degree program were more likely to complete the distance education course or program (Coggins, 1988; and Powell et. al., 1994).

Social Interaction Models

Social interaction has been shown to be a significant factor in determining distance education success. Individuals who prefer a collaborative learning style, where interaction with other learners is important, are less likely to succeed in a distance education environment (Dial & Cartnal, 1999).

A recent study examined the implementation of groupware into an asynchronous learning environment and found that groupware facilitated the group learning process (Becker & Dwyer, 1998). This study also investigated visual/verbal learning preferences of the students. A comparison of visual/verbal learning styles to independent/dependent learning styles has not, to my knowledge, been conducted with respect to distance education. However, accepting the fact that dependent learners learn best when interacting with other students or teachers, a preference for verbal learning would include dependent learners. Interestingly, Becker and Dwyer found that students who were categorized as more visual learners perceived an added benefit from utilizing groupware and considered the groupware to be valuable in the group learning process.

Information Processing Models

The amount of information processed and the amount of information learned are influenced by an individual's self-concept as a learner, distinct personal goals, expectations of success or failure, and preference, or lack of preference, for structured learning activities (Gibson, 1996; Wagner and McCombs, 1995; Dunn, Griggs, Olson, Gorman, & Beasley, 1995). Research studies in distance education have linked field dependence/independence with academic achievement (Ching, 1998; and Powell et. al., 1994;). Learners who prefer a more structured learning environment are learners who prefer a dependent learning style (field dependent). These learners are less likely to succeed in a distance education environment (Powell.et.al., 1994;). As the degree of learner control of the distance education environment increases (or structure is decreased), dependent learners reported that they "got lost" when studying or were unsure of the instructor's expectations (Ching, 1998; and Gibson, 1996).

In a study examining the amount of learner control in a hypermedia environment, active (independent) learners performed best with high levels of learner control, and reflective (dependent) learners performed best with low levels of learner control (Rasmussen & Davidson-Shivers, 1998). In a study of forty-eight sixth-graders, a structured presentation of material facilitated learning better than an unstructured presentation of material when using computer based instruction (Yang & Chin, 1996).

In a distance education nursing program, a study demonstrated that a field dependent learning style is a good predictor of poorer academic performance (Ching, 1998). This study also demonstrated that development of field independence could be influenced by the curriculum and teaching approach. Ching compared the field independence of students beginning distance education study to their field independence at the end of one year of study and found that field independence increased in these students. Ching attributed this increase to the distance education environment on the basis that this distance education course was taught to isolated students that had no formal means of student-to-student interaction. However, many students did indicate that they created their own student study groups that would foster the field dependent students' learning.

Conclusion and Future Studies

Learning styles are a preference in how a learner interprets and processes information. Most of the learning style instruments measure learning styles in terms of binomial opposites (i.e., dependent/independent and verbal/visual). However, learning styles are not absolute opposites; they are measurements of a continuum between these binomial opposites. Learners prefer a certain mode of learning, and are not locked into one mode of learning. In the study of Chinese nursing students, it was demonstrated that a student's learning style could change over time (Ching, 1998).

One consistent finding in the research on learning styles in distance education was the outlook for the dependent learner. The independent learner was more likely to succeed in a distance education course or program than a dependent learner. The dependent learner may be a good predictor of poorer academic performance.

To date in distance education research, most of the studies in learning styles have used samplings of convenience.

Also most of these studies were conducted on students who chose to take the distance education course over a traditional course offered at the same institution. In general, independent students usually self-select to the distance education course while dependent student self-select to the face-to-face courses. With the use of distance education in universities to deliver courses throughout a system where students are distributed among campuses in different cities, the choice of taking a traditional face-to-face course may not exist. Therefore, future studies should examine the dynamics of learning styles when the student has no choice but a distance education course or program.

Addressing Multiple Learning Styles in Web-based Instruction

The purpose of this literature review is to report current research addressing how Web-based instruction and the technological capabilities of the World Wide Web have been used to meet the individual learning styles of students. This review will look at research in the areas of learning styles and World Wide Web technology.

The area of Learning Styles has been researched extensively throughout the past fifty years. Much of this research has been conducted in the traditional classroom setting. The majority of research supports matching the individual's learning style with a complementary mode of instruction. Researchers agree that learning styles represent the ways in which individuals interpret, process, understand, and integrate information. Learning styles are defined in many different categories and inventories, none of which are standardized across the research. This makes it difficult to apply general conclusions across the research findings. Since much of the research on learning styles supports teaching students to their individual learning styles, for greater academic achievement, and shows support for the need to address multiple learning styles in every instructional lesson, this literature review is not limited to any specific learning styles categories or inventories.

The research in the combined areas of learning styles and Web-based instruction is very limited. The research that has been reported used mainly undergraduate college students as samples. Little is known or has been reported about addressing learning styles in Web-based instruction, for K-12 students. This appears to be an area requiring further research.

Learning Styles

Extensive research has been conducted in the area of learning styles in the traditional classroom setting. A great majority of this research has supported the fact that each individual differs in the way they interpret, process, understand, and integrate information. Research shows that people exhibit significant individual differences in the cognitive processing styles that they adopt in problem solving and other similar decision making processes (Robertson, 1985). Individual differences in student learning are categorized into learning styles. Learning styles are the ways in which the brain interprets processes, understands, and integrates information. Dunn, Dunn, and Price (1989), state that classrooms need to concentrate more upon individual learning styles because students tend to learn and remember better and enjoy learning more when they are taught in a way that takes into account for their learning style preferences. When developing instruction to accommodate learning styles, the instructional developer must know what delivery mode best suits each learning style type. When applying learning styles to the curriculum, Dunn & Dunn (1978) state that students should be taught to their dominant learning style and then followed with their second strongest learning style. Auditory learners learn best when they listen, read, and then take notes. Visual learners learn best when they read, look at visual aids, took notes, and then listened to a lecture on the material. Tactile learners require manipulative materials in which they can use to construct and then read, write, and listen to the material. Kinesthetic learners prefer exposure to the real world, such as field trips, followed by reading, writing, and listening to the material. A case study, by Hodges (1982), shows how putting these learning styles strategies into action can increase student achievement. The study was conducted with Junior High school students, from extremely low socioeconomic backgrounds, who were not responding to conventional strategies for learning. Each student was given a Learning Style Inventory test and an individual curriculum was matched with the student's dominant learning style. Results indicate that eighty-five percent of the students substantially increased their achievement levels in reading and math compared with their previous performance in a typical school setting. The data revealed that, when learners are taught through methods that complement their learning style preferences, learners become more motivated and have higher academic achievement.

Robotham (1995) questions the practice of placing students into pre-specified learning style categories. The author believes that this causes students to become stagnant in their ability to understand how they learn. The author believes that forcing students to learn, using different learning styles, can help them grow. Snider (1990) also states that it is good practice to recognize and accommodate individual differences and to present information in a variety of modalities. This research shows support for providing instruction that addresses multiple learning styles, within one lesson. With the advanced technological capabilities of the World Wide Web, it is possible for students to have exposure to a variety of instructional delivery methods that can accommodate multiple learning styles.

World Wide Web Technology

Some current capabilities of Web development software and World Wide Web technology have allowed teachers to expand upon traditional text and lecture based classes by creating individualized lessons that are aligned with teachers' lesson plans and individual students' competencies and abilities. Some current Web development software tools include, Microsoft Front Page, Macromedia Flash, Hyper Studio, Claris Home Page, and Power Point. This Web development software also allows each student to meet his or her individual needs, by selecting a unique course of instruction, through non-linear, branching structures. Students can direct their own learning by pursuing their interests and organizing and synthesizing data and constructing projects that are meaningful and can be applied to real life situations. Ayersman and Minden (1995) state that hypermedia has the ability to deliver information in contextually meaningful sequences, at a variable pace controlled by the learner, through multiple sensory modalities. Summerville (1997) states that hypermedia holds great promise for the accommodation of individual differences. Hypermedia has the ability to be flexible or structured, provide varied feedback, and allow the user to access other resources.

Some of the current features in multimedia Web development include the use of audio, video, virtual reality, animation, and simulation. RealAudio provides music, news, and talk shows over the World Wide Web. Java is a programming language that lets Web page developers add software applications, games, animation, and other features to Web pages. Shockwave enables the playback of high-impact multimedia on the Web and Virtual Reality Modeling Language (VRML) describes how three-dimensional scenes are delivered across the World Wide Web (Serim & Koch, 1996).

The World Wide Web can be used to accommodate students with diverse styles in processing sensory information, such as visual, auditory, and kinesthetic learners (Ross, & Schulz, 1999). Visual students can benefit

from World Wide Web instruction that includes course animations, hypertext, or clickable diagrams and video clips. These images can clarify concepts that static textbooks cannot. Learners who have difficulty processing auditory information in a lecture could benefit from having the professor's lecture notes, slide presentations, or overhead slides online. Auditory learners can benefit from Web-based instruction by having professors record their lectures, record class summaries, or create archived sound resources and place them online (Ross, 1998). Kinesthetic learners can benefit from Web-based instruction by providing them with Java based puzzles, games and simulations. Providing a course listserv, bulletin board, discussion thread, or chat room can also accommodate collaborative learners (Ross & Schultz, 1999).

Lin and Davidson (1996) found that when using hypertext instruction, structure and cognitive style had a significant effect on student performance. Research has shown that learner control is an important factor when creating Web-instruction for diverse learning styles. Learner control is the amount of personal responsibility an individual can have in an instructional lesson. Learner control in Web-based instruction can be exhibited through sequencing, pacing, advisement level, practice, and amount of material (Rasmussen & Davidson-Shivers, 1998). In a study conducted by Rasmussen and Davidson-Shivers (1998), the influences of the individual differences in learning styles and the concept of learner control to assist instructors and developers in designing effective instruction for all learners were investigated. They hypothesized that learning styles can be used in conjunction with learner control to facilitate and enhance student performance in hypermedia learning environments. The study found that learning styles significantly influenced performance in hypermedia learning environments. Individuals who had a learning style preference towards active learning preferred low levels of learner control and performed best in the hierarchy structures. The hierarchical structures allowed students to quickly accomplish tasks, which fits the style of the active learner who prefers to complete tasks as quickly as possible. Individuals who were reflective in their learning style preference performed highest with moderate structure. The results show that reflective learners must have some structure but must also be provided with the ability to explore other related material. In addition, all learners performed well in an environment that provided moderate structure. This research suggests that environments with high levels of learner control may be counterproductive to all learning style types.

World Wide Web and Learning Styles

World Wide Web technology has the capability of meeting the individual needs of a variety of learner types within each Web-based lesson. Much of the instruction taught in schools benefits the auditory and visual learners. Other learning style types are often not focused on in the classroom. Although research on Web-based multimedia instruction and learning styles is extremely limited, the following examples have been found that support the use of Web-based multimedia instruction for meeting the diverse needs of learners. For example, tactile learners gain and attain information when they are given hands-on activities (Dunn & Dunn, 1978). These students can respond well to game-like activities that are naturally motivating and self-correcting. Students can use the self-correcting features to discover correct answers through inductive and deductive learning (Bruno, 1982). An example of a game activity that can be beneficial to a tactile learner is the microworld. A microworld is an exploratory learning environment, discovery space, and constrained simulation of real-world phenomena in which learners can navigate, manipulate or create objects, and test their effects on one another (Jonnassen, 1996). A study conducted by Stoney & Oliver (1999), explored the notion that students who learn in an applied setting, such as a microworld, will experience cognitive engagement and motivation through the relevance of the material to the student's real world. University students were selected and their activities, communication, and interactions were observed. Results found that the use of well-designed interactive microworlds leads to learner cognitive engagement and will drive learners towards greater levels of higher order thinking. The microworld game also provided motivation and engagement with the program content because it provided real life experience. The game helped learners to judge and assess the credibility of potentially conflicting information and to develop strategies to think critically, resolve conflicts, and solve current and potential problems.

The California State University Biology Labs On-Line Project (Bell, 1999) is a project that seeks to use technology for improving biology education. This project provides Web-based simulations for different Biology labs in which learners can access anywhere and anytime. Initial tests on the Biology project have suggested that the programs can be very useful learning tools. Students liked the way the simulations made them think, solve problems, and understand the breadth of the material better. The one disadvantage noted was that novice computer users require assistance to get the most out of the simulations.

An additional case study involving a college Engineering Graphics class, at the University of Texas, has used the World Wide Web to publish a comprehensive multimedia instructional CD-ROM Web page (Crown, 1999). The CD-ROM Web page consists of an integrated web site with links to hours of tutorial movies, lecture presentations, web-based games that reinforce course topics, and interactive web-based quizzes. The CD-ROM Web page was designed to make more efficient use of faculty time and to provide students with additional individualized

help. This project had many positive results on both faculty and students. Professors benefited by having their course lecture time reduced by eighty percent. Students who require extra help or need to make up work were able to catch up and perform well in the course. The visualization tools, provided in the games, offered students the opportunity to view objects repeatedly, which would be difficult to teach using other methods. Two noted drawbacks to the CD-ROM Web page include the high initial cost in time to develop the project and the fact that this environment has less student-to-student interactivity and is more impersonal than traditional classroom lab settings. The most notable changes in student performance were by those students that fell outside the average range. The advanced students were stimulated and motivated by the self-paced nature of the course and the students who found the material challenging were able to work at a slower pace and finish a course that they normally would drop.

Conclusion

Little Research has been done on addressing multiple learning styles in Web-based instruction. The literature shows strong support for matching learning activities with students' preferred learning styles. Web-based instruction allows for the development of instruction that can meet a variety of learning styles. It can address multiple learning styles within the same instructional lesson. Therefore, it is hypothesized that students will perform better and learn more from properly designed Web-based instruction that meets the many individual learning styles of students, than Web-based instruction that is linear and text based. Since World Wide Web technology and multimedia software is capable of supporting instruction that appeals to a variety of learning styles, and research suggests that students must also be exposed to other non-dominant learning styles, a Web-based instructional lesson that accommodates multiple learning styles should be ideal for enhancing student achievement. When addressing the no significant difference phenomena, the research presented in this literature review supports that there are significant differences in student achievement, in a Web-based environment, when instruction is developed using theories on the way students learn. In order to look beyond the no significant difference phenomena, Web instruction must go beyond the technology and look into how the technology can be used to deliver instruction to all students, each unique in their experiences and in the ways they learn. Integrating learning styles research into Web-based instruction is one way that may show a significant difference in achievement in Web-based instruction.

Application of Intelligent Agents in Web-based Learning Systems

How will the Intelligent Agents (IAs) and World Wide Web (WWW) architecture impact education in the future? Perhaps learning will resemble this imaginary encounter:

> The twelve-year-old girl enters a room containing a wall display and an electronic unit about the size of the obsolete desktop PCs of a decade ago. Her "learning center" is a voice activated intelligent appliance linked directly to a database via the new Information Superhighway.
>
> "Computer on," she commands.
>
> The computer synthesized voice responds, *Good morning Genevieve. School was to begin 27 minutes ago. Are you ready?*
>
> "Yes," she replies rather unenthusiastically.
>
> *I recommend beginning with Statistics. You are now one week behind your agreed schedule,* the course management agent continues.
>
> "Great!," the girl responds with even less enthusiasm than before.
>
> *I'm sorry. Is that an affirmative Genevieve?*
>
> "Yes"
>
> The display screen next shows the animated face of a dog wearing glasses (the girl's creation). *Genevieve, good to see you. Your reflective time is over. Are you ready to review your last exam?*, the animated persona smiles with lolling tongue awaiting the girl's voice response.
>
> "Not really, but OKAY Topper" (The girl's name for her animated tutor). She smiles as she emphasized the command word "okay."
>
> *You completed 30 of 50 questions correctly,* Topper continues.
>
> "I figured as much"
>
> The animated persona looks quizzical and responds, *Yes. Well, it appears that you are having difficulty relating the concept of the normal distribution to the concepts of standard deviation and confidence intervals. Do you want to review the material or try a new approach.*
>
> "I'll try the new approach." And the lesson begins.

At what point in the future will technology and software combine to produce the scene above? As prototypes and experimental models, this future is already here.

Alan Turing and Moore's Law

In a 1950 article, Computing Machinery and Intelligence, mathematician Alan Turing posited the question, "Can a Machine Think?" (Hodges, 2000). To Turing the question was: "If a computer could think, how could we tell?" He considered that if the computer's responses were indistinguishable from that of a human, could the computer be said to be thinking. Turing set a standard for determining intelligence or thinking by making a prediction. He postulated that within fifty years (i.e., the year 2000) an average person would not have more than a 70 percent chance of distinguishing between a computer or human responding to five minutes of questioning. Turing's imitation game has now become known as the Turing Test. In 1990 philanthropist Hugh Loebner agreed to underwrite a contest to implement the Turing Test. The contest is conducted each year by The Cambridge Center for Behavioral Studies (http://www.loebner.net/Prizef/loebner~prize.html). A grand prize of $100,000 and a Gold Medal will be awarded to the first person constructing a computer that passes the Turing Test. Although this prize has yet to be claimed, each year an prize of $2000 and a bronze medal is awarded to the individual constructing a computer program offering the most "human" responses.

In addition to software advances required to pass the Turing Test technology must also progress. Moore's Law is based on the observation that the logic density of silicon integrated circuits follows a mathematical curve. According to its author Gordon Moore (who co-founded Intel) the amount of information storable on a given amount of silicon has roughly doubled every year since the technology was invented. In the 1970s the rate of doubling slowed to 18 months, and Moore predicted that natural limitations would invalidate the "Law," but not until 2017 (Kanellos, 1997).

In a broader view both the Turing Test and Moore's Law are illustrative of the first steps toward an ideal where economical intelligent machines serve the needs of the individual. This paper will examine the development of intelligent agents and forecast applications for education deliverable on the World Wide Web (WWW).

Intelligent Agents

'Intelligent agent' as a concept has been around for about 25 years. An agent is a software entity that has some degree of autonomy, carries out operations on the behalf of a user or another program, and represents or has knowledge of the user's goals and wishes. Definitions approach intelligent agents based on how the term "intelligent" is defined. Science fiction genres tend to associate intelligent software with human-like emotional and mental processes such as knowledge, belief, intention, and obligation (Coen 1994). Utilitarian definitions of intelligent agents focus on a particular software's ability to function in some complex dynamic environment, and to sense and react autonomously to achieve a set of behaviors. Intelligent agents can also simulate worlds and operate in those simulated worlds interacting with the users and other agents. Information agent software searches multiple databases to retrieve, collate, filter, and organize information to answer queries from users (Shoham, 1993). A list of attributes of agents, not all of which need to be present in an agent, are:

- Autonomy – ability to operate without the direct intervention of humans;
- Social ability – can interact with other agents or humans by providing assistance to users dealing with another agent;
- Reactivity - have perception of their environment which allows timely response to changes that occur in it;
- Proactivity - exhibit goal-directed behavior (initiative);
- Mobility - can move to other environments;
- Reusability - agent algorithms run continuously;
- Adaptivity – will automatically adapt to changes in their environment; and
- Synergism - higher level of interoperability is made possible through the interaction of agents and humans as a system (Shoham, 1993).

There are many categories that research on intelligent agent systems and similar software applications have been subdivided. For example, adaptive learning systems, artificial intelligence, artificial life, biocybernetics, cognitive and neural modeling, evolutionary computation, fuzzy systems, genetic algorithms, knowledge-based systems, multi agent systems, neural networks, parallel and distributed computing, self-organizing systems are terms associated with the above attributes for intelligent agents. Furthermore, each of these categories is being researched for applicability to learning on the WWW.

Intelligent Agents and Tutoring Systems on the WWW

With the World Wide Web becoming an increasingly important platform for the delivery of educational content, instructional designers and researchers in artificial intelligence are reconsidering architectures that were

developed for stand-alone computer or local network applications (Ritter, 1997). Intelligent agents are being developed for many of the new applications (Johnson & Shaw, 1997). Areas of intelligent agent research that show promise for educational applications deliverable through the WWW are briefly described in this paper.

Intelligent Agents Used for Database Management and Information Retrieval

The WWW can be viewed as an extremely large database. This database is composed of heterogeneous documents that are accessed via a wide-area network (WAN) and a client-server protocol. These documents (nodes) are connected by hyperlinks. To retrieve information hyperlinks must be navigated and navigation becomes extremely difficult in the three-dimensional structure of the WWW (De Bra & Post, 1994).

Intelligent agents have the potential to search the vast volume of information on the Web in ways that are only now being explored. Agents have advantages of (1) robustness – available 24 hours a day, seven days a week, (2) speed – transmit information within seconds, and (3) value adding – the more sophisticated the agent in terms of design for ability to discover relevant information the more tangible the benefit from the information (Etzioni, 1999). Etzioni and colleagues at the University of Washington are researching and designing Internet Softbots (intelligent agent software) that will enable a user to specify personalized *wants*. The Softbot is designed to calculate the *how* and *where* to satisfy the request. Etzioni uses the metaphor of a food chain or pyramid to visually describe the role that a discriminating information agent would play in this new information "ecosystem" of the WWW. Developmental work is also being done by Etzioni's group on adaptive Web sites that automatically reconfigure their layout and presentation by analyzing user access patterns recorded in their server logs (Perkowitz & Etzioni, 1997).

Intelligent Agents and User-Friendly Interfaces for Databases

The use of an animated persona to communicate information has recently caught the interest of the news media. The highly publicized virtual newscaster Ananova (Hopper, 2000) is an example. Using streaming video Ananova provides the latest headline news. Facial expressions are cued by XML (eXtensible Markup Language) tags that are added to the script. Digital Animations Online (http://www.digital-animations.co.uk/) is the creator of Ananova.

Customizable animated intelligent agents. Customizable animated intelligent agents are available to Web developers to enhance the commercial value of a Web site. These virtual personalities can assist a visitor to the site in identifying products, guiding the visitor through product features and benefits, or even making the "sales pitch" and closing the sale. The animated persona can interact with the user by answering queries including the display of facial features ascribed to various human emotions. Animated personas are proposed by their developers as adaptable for use by educators.

Intelligent Agents Facilitating Collaboration in Online Courses

A significant problem experienced by students (as well as causing concern for instructional designers of online courses) is how to facilitate collaboration in a largely asynchronous environment. Typical problems expressed by students working as groups in a face-to-face environment are "lack of time, lack of skills and members not contributing" (Whatley, Staniford, Beer & Scown, 1999). These problems are made more manifest in collaborating groups separated geographically (Johnson, Aragon, Shaik, & Palma-Rivas, 2000). In order to facilitate collaboration intelligent agents are able to support planning through task allocation, progress monitoring, and problem flagging (with communication with the individual student as well as with the agents of other students).

O'Riordan and Griffith describe an multi-agent system design where several intelligent agents that the authors believe will overcome specific web-based education shortcomings in the areas of peer-peer learning, static content, and personalized learning (O'Riordan & Griffith, 1999). Their system design focuses on a User Modeling Agent that maintains the student profile. The profile consists of material covered and how fast its was covered, quiz score, frequency of links visited, and use of an FAQ section. Collaborative groups are based on multiple profiles.

Intelligent tutoring systems. An Intelligent Tutoring System (ITS) is designed to simulate what occurs between a student and teacher one-to-one. ITSs typically have four components: (1) an intelligent interface (communication), (2) a knowledge domain, (3) an instructional module, and (4) a student model (representing the student's current state of knowledge). Student modeling has been the most difficult due to the learner uniqueness and individual learning styles (Stern, 1997).

Most models of student behavior commonly used with intelligent tutoring systems (ITSs) or not designed to deal with such human inputs as inconsistency, incompleteness, and ambiguity. Often this "fuzziness" of human input results in an inability of the ITSs to correctly evaluate student answers. Huang approached this problem by developing a model that incorporates fuzzy set theories and two-dimensional (Hasse) diagrams to provide more accurate feedback to incomplete student answers (Huang, 1999). The learning agent captures inconsistent behaviors of the student. A student's inconsistent response, for example, triggers the learning agent procedure that uses a inconsistency identifier. The inconsistency identifier is based on a heuristic, such as on the same or similar question

the student's answer is now incorrect. The feedback from the learning agent then displays features of the inconsistencies and provides suggested strategies to prevent the behavior from happening again.

Animated pedagogical agents. Animated pedagogical agents are designed to facilitate learning in computer-based instruction, and also have been applied to Web-based intelligent tutoring systems (Rickel & Johnson, 1997). Typically, animated agents have personas that can exhibit emotive-kinesthetic behaviors responding to user input within the program (Lester, Stone & Stelling, 1999). Pedagogical agents are built upon ITS research, but have the added requirements of coordinating the agents behavior with personality cues that relate to student input (Lester, Towns & FitzGerald, 1999). Animated agents can provide real-time advice that supports a learners' problem solving activity, but can also exhibit contextually appropriate emotive behaviors such as facial expressions and gestures. Lester, *et al* identify two key problems with representing emotive behaviors are conversational believability and emotive believability, and have developed a dialogue mapping framework to achieve conversational believability and full-body emotive behaviors in response to learner problem solving activities to achieve increased emotive believability.

An example of a prototypical animated intelligent agent is was developed by Andre, Rist, & Muller (1997). Their agent did not involve speech, but with animated gestures and text interacted with the user. One unique feature of their animated agent was that the presentation scripts and navigation structures were not storied, but generated just-in-time from pre-authored document fragments.

Adele (Agent for Distance Education) is an example of a more sophisticated animated pedagogical agent developed by researchers at the Center for Advanced Research in Technology for Education (Shaw, Johnson & Ganeshan, 1999). Adele was specifically designed to support online students in problem-solving exercises with a simulated patient in a clinical setting. Students are able to ask questions regarding the simulated patient's medical history, perform a physical examination, order diagnostic tests, and make diagnoses. Adele also provides the student feedback relative to the actions chosen by the student in the form of suggested correct actions, or hints and rationales for particular actions with reference to relevant background material. In this autonomous agent design, Adele consists of two sub-components: the animated persona (a Java applet) and the reasoning engine. The reasoning engine performs all monitoring and decision making activities. Decisions are based on a student model, the case design, and the initial state of the case. All this information downloaded from a server when as the student selects the case. Initial student evaluations of Adele concluded that the hints and rationales provided by the animated agent were helpful, but not complete. However, this appeared to be a function of the students not interacting with the persona, for example, asking "Why?" The agent was capable of accessing more authored knowledge. This problem was remediated by allowing the agent to provide more of an explanation.

Conclusion

The significance of intelligent agent systems on the WWW will probably eventually be best understood in the context of a paradigm shift. The combination of technology in terms of software and hardware, and the delivery and accessibility afforded by the WWW, is creating an environment of change. The impact of change on institutional or traditional education is in the infancy of exploration.

Web-based educational systems represent an area that growing exponentially with educational technology research and software development leading the way. Pedagogical aspects such as instructional design theories and models have lagged behind (Tergan, 1997). In many respects the situation facing educators is similar to the company that designs a product and goes out to find a market for it. The technology is driving the process and instructional theory and design are attempting to "find the market."

This situation may be due to the fact that much of the developmental research work on Web-based IA software being done for commercial objectives. Major efforts in IA research and design are directed toward e-commerce applications on the WWW. Software agent technologies are being investigated to expedite the electronic commerce revolution. E-commerce development issues, such as distributed component-based marketplaces, protocols for locating and defining goods and services, value-based product comparisons, buying decision aids, visualization of marketplace data and activities, have pedagogical counter-parts in education.

Intelligent agent systems that support student collaboration, support problem solving, and explain errors will certainly be a first step. How will Web-based distance education benefit from this development? The development of quality databases on the WWW coupled with the development of intelligent agent software that can retrieve personalized information. Will a student having greater access to knowledge be a better learner? What instructional designs will be necessary? Are animated personas described in this paper, that guide a student through a lesson or topic, an advantage to learning or a distraction? Opportunities abound for the researcher in both the design and in the development of instructional models that incorporate intelligent agents and the WWW.

Summary

The four approaches presented here support the need for continued exploration of distance education from new perspectives. The use of CAI is not new. However, the use of CAI as the technology of choice for distance education in the K-12 setting has potential. CAI's capabilities of individualizing instruction and providing asynchronous instruction combined with the richness of the World Wide Web need further exploration as an effective and cost efficient means of providing access to educational opportunities for K-12 students.

More studies into learning styles of distance learners are needed that control for the problems identified in the current literature in this area. Sampling needs to be moved from simply relying on convenience sampling. In addition, standardized instruments need to be developed to examine this learner attribute. Designer's of distance education need to address the needs of the dependent learner and student support services developed to assist these learners in having success in the distance education environment. When reviewing learning styles and web-based instruction, there appears to have been little research. From a design perspective can and should web-based instruction be designed in such a way to accommodate all learning styles?

New technologies are constantly emerging. How will the use of intelligent agents impact the learning environment particularly distance education? Instructional technology has a tendency to lag behind technology advancements. Exploring the utilization of intelligent agents to support student collaboration, problem solving and provide assistance in the distance learning environment would be one step toward closing the gap.

Certainly, thinking of distance education research only in terms of the no significant difference does not represent the wealth of research that is occurring in the field. However, as researchers we can do more by looking beyond the conventional, looking at new uses for current technologies, and exploring the potential of emerging and future technologies.

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