Designing Effective Computer-Based Learning Materials

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INTRODUCTION

This entry begins by discussing the history of computer-based learning (CBL), followed by a description of learning theories and instructional design models that are being used to design CBL materials. The chapter concludes by proposing a model for designing CBL materials. The model proposed is based on current instructional design models but goes beyond these models by suggesting the use of intelligent agents to capitalize on the power of the computer in CBL. Instructors and tutors working in CBL one-to-one environments claim that it takes more time to design, develop, and deliver instruction when compared to face-to-face delivery. The main reason for extra time is the lack of use of the power of the computer in CBL. The author is suggesting the use of intelligent agents in the design, development, and delivery of instructions in CBL. Intelligent agents can be used to conduct learner analysis after interacting with the learner, assemble the content, and prescribe instructional strategies for individual learners after forming a profile of the learner. Intelligent agents can also be used to manage learners' interaction and participation in the CBL process, freeing the tutor to do other human-related tasks. Wooldridge and Jennings (1995) defined an intelligent agent as a computer system that is capable of flexible autonomous action in order to meet its design objectives

Instruction and training are not new to humans; what has changed is the way the training is conducted. During the early ages, experienced family members trained younger individuals in one-to-one coaching and mentoring situations. There were no formal schools or modern technology to deliver the training. Most of the training was done verbally and with technology that was available at the time; for example, information was passed on by using sticks to draw in the sand or writings and drawings on walls with stones. The information was not recorded permanently for learners to refer back to when needed. With the invention of paper and the printing press, information was recorded and then utilized for training. This was followed by the advancement of computer hardware and software, which allowed learning materials to be developed in an electronic format. In the early 1960s, learning materials were designed and developed on mainframe computers to train workers without an instructor being present in a face-to-face mode. In the 1970s, computer-based training systems used minicomputers to train employees in the workplace and students in the education system. Beginning in the 1980s, the microcomputer revolutionized the design and delivery of CBL materials. The microcomputer gave the teacher and the students control of the hardware and the software. The teacher was able to design CBL materials using authoring systems, and students were able to learn when and where they wanted to learn, which improved the effectiveness of CBL. Research studies (Kulik, Kulik, & Shwalb, 1986; Lawson, 1999; Wesley, Krockover, & Hicks, 1985) have concluded that CBL is as effective, and in some cases more effective, than traditional classroom instruction; however, some researchers claim that it is the extra amount of time spent on the design that makes CBL more effective than classroom instruction rather than the technology (Allen, 2003; Clark, 1983, 2001; Kozma, 2001).

How Learning Theory Impacted the Design of CBL

Early instructional design theory was influenced by behaviorist theory and was used to design and develop early CBL systems. The behaviorist school of thought, influenced by Thorndike (1913), Pavlov (1927), and Skinner (1974), postulates that learning is a change in observable behavior caused by external stimuli in the environment. Behaviorists claim that it is the observable behavior that indicates whether or not the learner has learned something, and not what is going on in the learner's head. The early behaviorists influenced Pressley (1927) to develop the teaching machine,

which removed the repetitiveness of teaching from the teachers to technology by using drill and practice as the instructional strategy.

Beginning in the 1970s, the design of CBL material was influenced by cognitive theory, which claims that learning involves the use of memory, motivation, metacognition, and thinking, and that reflection plays an important part in learning. Cognitivists see learning as an internal process and claim that the amount learned depends on the processing capacity of the learner, the amount of effort expended during the learning process, the depth of the processing (Craik & Lockhart, 1972), and the learner's existing knowledge structure (Ausubel, 1974).

Cognitive psychology looks at learning from an information-processing point of view, where the learner uses different types of memory during learning. Sensations are received through the senses into the sensory store before processing occurs. Effective CBL materials must use strategies that allow learners to attend to the learning materials so that the information can be transferred from the senses to the sensory store and then to working memory. The amount of information transferred to working memory depends on the amount of attention that was paid to the incoming information and whether cognitive structures are in place to make sense of the information. Strategies that check whether learners have the appropriate existing cognitive structure to process the information must be used in CBL. If the relevant cognitive structure is not present, preinstructional strategies, such as advance organizers, overviews, and concept maps, should be included as part of the learning process (Ally, 1980; Ausubel, 1960).

CBL materials should use a variety of learning strategies to accommodate individual differences. Different learners will perceive, interact with, and respond to the learning environment in different ways based on their learning styles (Kolb, 1984). CBL materials should include activities for the different styles so that learners can select appropriate activities based on their preferred learning style. The power of the computer can be used to determine a learner's existing level and style, and prescribe the appropriate learning sequence and strategy based on the learner's level. Learners come to the learning process with their own metacognitive strategies that were obtained in previous learning situations. CBL systems should encourage learners to use their existing metacognitive skills to help in the learning process (Sternberg, 1998). Metacognition is a learner's ability to be aware of his or her cognitive capabilities and use these capabilities to learn. Exercises with feedback throughout a lesson are good strategies to allow learners to check how they are doing so that they can use their metacognitive skills to adjust their learning approach if necessary.

Recently, there has been a move to the use of constructivist theory, which claims that learners interpret information and the world according to their personal reality, and that they learn by observation, processing, and interpretation, and then personalize the information into their own worldview (Cooper, 1993; Mezirow, 1991; Wilson, 1997). Learners learn best when they can contextualize what they learn for immediate application and to acquire personal meaning. This poses a challenge to the designers of CBL materials since the system has to have enough knowledge of the learner to contextualize the material for the learner to personalize the information.

According to constructivism, knowledge is not received from the outside or from someone else; rather, it is the learner's interpretation and processing of what is received through the senses that creates knowledge. The learner is at the center of the learning, with the tutor playing an advising and facilitating role. Learners should be allowed to construct knowledge rather than being given knowledge through instruction (Duffy & Cunningham, 1996). Constructivists view learning as the result of mental construction where students learn by fitting new information together with what they already know. According to Ausubel (1974), it is important to determine where the learner is coming from and teach from there to make the learning more meaningful and personal. Tapscott (1998) suggested that learning is moving away from one-way instruction to the construction and discovery of knowledge. The challenge for instructional designers is how to design CBL systems to integrate the theoretical and the practical, and then facilitate learners to contextualize and personalize the learning (Eichler, Goncalves, da Silva, Junges, & Pino, 2003).

CURRENT INSTRUCTIONAL DESIGN MODELS FOR CBL

There are many existing models that are being used internationally to design CBL materials. The U.S. De-