

POPULAR THEORY SUPPORTING THE USE OF COMPUTER SIMULATION FOR EXPERIENTIAL LEARNING

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ABSTRACT

Computer simulated environments have advanced significantly in the past 10 years. Recent advancements in graphics and processor technology have allowed for the creation of realistic electronic environments that closely replicate the job environment. Promising research and development in the areas of virtual reality and simulation engines are yielding glimpses of how future training and education may be delivered.

Developers of Computer Based Training and Instruction (CBT and CBI respectively) are finding that customers are making the connection between on the job performance and interactive simulation. But still, many are reluctant to include computer based simulation in the development of instructional material. This paper explores popular theories in learning psychology and how they support the case for computer simulation inclusion in CBT and class room education.

A PLACE FOR EXPERIENTIAL LEARNING

Education and training are often criticized for providing information without practical application to the real world (Whitehead 1929, Rogers 1969). Rogers distinguishes between two types of learning: cognitive, which is described as meaningless, and experiential, labeled as significant. The cognitive learning to which Rogers refers, and what Whitehead refers to as inert knowledge, is content that is delivered to learners in the name of knowledge. Information such as specific dates in history or a list of state capitals, has little application value when performing job tasks. Both authors point out that knowledge has very little use unless it is associated with a real world application.

Rogers perceives experiential learning, or knowledge which is gained through the discovery of new information during the application of prior knowledge, as significant. The justification for the segregation of the two types is that experiential learning is typically initiated by the individual out of necessity, thus relevance to the learner's reality is established immediately.

Experiential learning is personalized to the learner by the nature of the experience. It allows individuals to place abstract concepts into context by providing an environment where the prior knowledge must be recalled.

Constructivist theory, where individuals draw upon prior knowledge to construct or form new schema, offers a foundation for discovery learning (Bruner 1960). When confronted with a new stimulus, individuals use their own knowledge-base to accommodate the new information and change their scheme in memory (Piaget 1964).

Immediacy in relevance is particularly critical in adult education. Adults are continually bombarded by new information and are quick to discard anything that may appear to be irrelevant. Therefore, including experiential learning experiences as part of class room or CBT provides the learner an opportunity to draw the connection between new information and the real world.

Empirical research confirms this conclusion. A study of engineering students using a computer simulation in conjunction with class room instruction yielded evidence that a substantial gain in retention of the subject matter was obtained as compared to students using only conventional teaching methods. (Firth 1972). In addition, the students viewed the simulation as an effective learning tool and perceived the events as realistic.

CONTEMPORARY FORMS OF ELECTRONIC ENVIRONMENTS CONDUCTIVE TO EXPERIENTIAL LEARNING

Today there are vehicles available to reinforce cognitive knowledge through the use a simulated environment created electronically. Both class room delivered and CBT content can be further enhanced by the use of tools such as simulation engines, role playing and games.

Typically, the simulations fall into one of two types; scaffolded and open ended. A scaffolded design would limit the responses or options that the users may select. An example of this would be a simulation of a locomotive control panel, where the learner can only input variables within a predetermined range. A spreadsheet simulation of a long range business plan is an example of an open ended simulation. In this situation the learner could substitute any value for the variables and the simulation would calculate the outcome. Open ended simulations are sometimes referred to as "what-if" scenarios.

In 1977, Keys offered an experiential learning model; "The Management of Learning Grid". The premise of the model was that there are three elements essential to effective simulation instruction; 1) the dissemination of new ideas, concepts and principles (content), 2) an opportunity to apply content (experience), 3) feedback based upon the actions of the learner. Computer simulations would contain elements 2 & 3, but also could include new information to be used during the exercise.

In addition to the above mentioned benefits of computer based simulation, the added bonus of multimedia technology has given instructional designers the tools of animation, video and sound to provide learners with working models that convey complex concepts. Even the best class room instructor would find it extremely difficult to match the ability of ADAM, the animated human anatomy software. In addition, multimedia CBT programs provides stimuli to auditory, visual and tactile learners in a fashion that grabs their attention as they pine to find out what will happen next in the simulation.

Computer simulations also compliment Gagne's 9 levels of learning model (Gagne 1985, See Table 1). These levels are an excellent lens through which one may view the environmental benefits of using computer simulation to enhance instruction. The next section of this paper provides examples of how simulation satisfies each level of the model.

LEVEL 1

The Multimedia revolution has provided the tools for captivating the learner. Through the use of multiple media (video, sound, animation, text, graphics, etc.) the learner's senses are heightened and primed to receive information. The attention of most individuals is easily gained and maintained through the learning experience. The speed of the simulation is manipulated by the individual, therefore faster learners are not bored and slower learners maintain control for their own optimum rate of knowledge acquisition.

TABLE 1. GAGNE'S NINE LEVELS OF LEARNING

Level	Event
1	Gaining Attention (reception)
2	Informing learners of the objective (expectancy)
3	Stimulating recall of prior knowledge (retrieval)
4	Presenting stimulus (selective perception)
5	Providing learning guidance (semantic encoding)
6	Eliciting performance (responding)
7	Providing feedback (reinforcement)
8	Assessing performance (retrieval)
9	Enhancing retention and transfer (generalization)

LEVEL 2

Before entering a simulation, the learner is presented with the objectives or goals of the exercise and is fully aware of the desired outcome. Unlike a class room setting, the variables of the experience can be monitored and held constant against the learning objectives.

LEVEL 3

Simulations offer learners an opportunity to apply content delivered in the class room, CBT lesson or obtained through life experiences. Simulations engage the learner to recall information to solve problems, and interpret principles or properties displayed by models. They can be used to assess an individual's skill level prior to entering an area of content or be used as a benchmark for task mastery.

LEVEL 4

The stimulus to which Gagne refers can be in the form of a problem solving scenario, adventure, puzzle or a job task in which the previously learned concepts are to be applied. At any time during the simulation, the learner can also recall the problem statement or rules of the simulation.

LEVEL 5

The nature of the simulation provides learning guidance. Features such as "show me" button, which display the solution, the correct process or solve the puzzle , can be built into a simulation. Other features such as job aids can also be incorporated so that the individual can refer to the steps of a process or key definitions, and further promote the recall of prior knowledge.

LEVEL 6

The desired performance is elicited from the learner as she works towards the objectives of the simulation. Exercises can be graduated in difficulty, thus building performance confidence and esteem. Higher levels of simulation difficulty motivate the learner to master target skills and encourage further knowledge acquisition. In addition, scaffolded exercises can reduce infinite responses from the individual and focus attention on a limited number of choices. Although limiting the number of choices reduces the impact of absolute discovery, it provides a guard rail to the learner and minimizes the chances of the individual succumbing to utter frustration.

LEVEL 7

Probably one the most beneficial features of a computer simulation is the ability to provide individualized feedback, based upon actions of the learner. Feedback in a scaffolded exercise can provide positive reinforcement, cause and effect experience, promote recall of prior knowledge and provide assessment information pertaining to task performance. The obvious advantage is that unless an individual tutor is assigned, it is unlikely that the individual will receive the level of customized feedback that can be delivered in a simulation.

LEVEL 8

Assessing performance and feedback are interlocking components of a simulation. Simulations provide a controlled environment in which performance can be monitored free from outside influences. Work environments can be replicated away from any danger of learning to perform job tasks in an actual production setting. The safe environment affords the individual an opportunity to learn by making mistakes and receive additional information in the form of instructive feedback. Performance assessment also provides the learner with information pertaining to her progress towards the mastery of skills set forth in the learning objectives.

LEVEL 9

Repetitive use of simulations enhances the retention of knowledge gained in the class room or CBT experience as well as experiential knowledge from the simulation. As the individual attempts to master the simulation, she will recall schema formed from previous experiences with the simulation, thus aiding knowledge transfer. From a constructivist point of view, each visit to the simulation will yield new knowledge as the individual draws upon the last visit to construct new strategies for reaching the objectives of the exercise.

Other supporting theory would including the Modes of Learning; accretion, structuring and tuning (Rumelhart & Norman 1878). Where the individual acquires new knowledge (accretion) prior to the exercise and then develops new conceptual structures or schema within the simulation. Revisiting the simulation affords the individual with practice and the opportunity to tune the knowledge to a specific task.

CONCERNS OF DESIGN

Bowen points out in a 1987 literature review that experiential learning has the greatest impact when it is 1) accompanied by emotional arousal, 2) takes place within a safe environment, and 3) gives adequate processing time with a clear summary providing a cognitive map of the experience. Bowen's points 2 and 3 are of concern to the simulation designer. Computer simulations, unlike the class room, provide the learner with performance feedback in private, thus increasing the opportunity for exploration without fear of public humiliation. This is of particular concern with adult learners who are prone to possessing a fear of failure. As mentioned previously in this article, simulations provide the learner with a safe haven for making mistakes. Most would agree that observing the ramifications of a student pilot stalling a 747 in a flight simulator is a learning experience, but the same experience would prove to be a tragedy at the airport.

Consequently, learning would not take place if the learner could not draw conclusions from the experience and assimilate the knowledge. Computer simulations provide the ability to deliver feedback on an individual basis and a summary at the end of the simulation. This provides the individual with specific information, associating the results with a specific mistake or knowledge deficiency, once again personalizing the experience.

Another area of concern for simulation design is face validity. As mentioned in the engineering student case, the simulation experience must appear realistic in nature to the learner. It is important that the simulation entice the individual to behave in a particular scenario as they would in a real situation (Keys and Wolfe 1990). The simulation must be free of barriers which would otherwise distract the learner from the objectives of the experience. Such barriers are unrealistic data or scenarios, user controls that are not intuitive and simulation interfaces that do not represent real world conditions.

DISCUSSION

Computer simulation affords teachers and instructional designers a powerful tool for sustaining knowledge retention and transfer. Experiential learning can provide the learner with a rich opportunity to construct new schema from prior knowledge obtained either in the class room or CBT. Empirical evidence suggests that the use of simulations significantly enhances knowledge transfer in students over traditional class room delivery methods.

Overall, interactive simulations involve the learner in the application of prior knowledge, thus stimulating recall. Individualized feedback can be delivered based upon the responses and actions of the learner in the simulation. In addition, sound, video, animation and other multimedia features appeal to multiple learning styles and capture the learner's attention.

The case that has been presented paints a picture of a learner's utopia. The design concerns listed can be overcome with careful instructional design and a thorough analysis of the task environment. So why are schools, universities and private industry still reluctant to embrace the technology? Cost could be a consideration, but simulations can be as low budget as a spreadsheet.

I predict that computer simulations will become a core component of educational curricula as the proverbial torch is passed from the current generation in power to the next. As the ship of history slowly changes course, we will wonder how people ever connected with the content without a simulated environment.

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