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ABSTRACT

Effective classroom simulations can provide opportunities for end-users to analyze human teaching and learning behaviors and can also help prepare teachers for real-world experiences. This paper proposes a simulation project based on an aggregation of ideas associated with knowledge-based simulations, behavior observations, visualization, and the team approach to product development. Knowledge-based simulations use special knowledge to boost run-time performance and fidelity, often relying upon disciplines such as game and probability theory for implementation. They can use virtual reality to offer navigation through, and three-dimensional viewing of, worlds in real time; the user's role shifts from passive to involved. For the project, a research team of computer programmers, instructional designers, videographers, graphic artists, behavioral psychologists, educational researchers, and a project manager was assembled. The team, taking into account issues of quantifying human behavior and depicting it via simulation, will: develop a knowledge base using several electronic databases; review new technology and software as they emerge; and carry on running discussions of feasibility and the formative evaluation process. (AEF)

Visual Fidelity and Learning via Computer-Based Simulations

by Glen A. Holmes

Abstract

This paper is founded upon the belief that human behavior is observable, measurable, and predictable. Successful attempts to quantify behavior known to occur in learning environments such as the K-12 classroom may lead toward the development of useful tools that aid educational practitioners in refining their own pedagogical knowledge and skill. This paper proposes a strategy for investigating such an idea.

Introduction

Computers serve as convenient and efficient tools for modeling and analyzing the behavior of real systems -- in other words, conducting simulations. Whereas modeling describes what a system *is* (for example, appearance and technical specifications), simulation can demonstrate what a system *does*.

Visualization is also important when designing simulations. It is only after something is visualized that a simulation can be used to investigate its behavior (Adams, 1994). However, just how much visual detail is necessary to effectively communicate during a simulation is debatable. Some argue that, the more detail offered through visualization, the better the communication of ideas. Other suggest that details of the media used during simulation may interfere with the message being conveyed (McCloud, 1993). In the case of classroom behavior simulations, one might argue that increased levels of abstraction may allow users to more closely identify with characters (objects) of the simulation and, consequently, gain more from the learning experience.

Visualization adds measurement, color, quantification, qualification, and other attributes to abstract phenomena. It provides a sense of purpose, making concrete what otherwise, may exist only as a product of one's imagination.

Classrooms can be viewed as educational microsystems in which a variety of human behaviors (both teaching and learning) might occur. Likewise, effective classroom *simulations* can provide opportunities for end-users to study and/or analyze these behaviors and perhaps, serve a useful purpose in the preparation of teachers (pre-service and/or in-service) for real world experiences. The strategy proposed below is an aggregation of ideas associated with knowledge-based simulations, behavior observations, visualization, and the team approach to product development.

Knowledge Based Simulations

Knowledge-based simulations use special knowledge to boost run-time performance and fidelity, often relying upon disciplines such as game and probability theory for implementation (Adams, 1994). These type of simulations use predicate calculus and if-then reasoning to achieve results and are well suited for applications that predict the likelihood of an event's occurrence. By broadly defining a game to be *any* activity, enterprise, situation, or endeavor between or amongst humans and combining this with probability theory, speculative scenarios (e.g., classroom situations) can be analyzed.

Difficulties in Quantifying Human Behavior

One way to gather data on human behavior is through repeated observations followed by some technique to reduce and quantify the data collected. One such reduction technique is that of Flanders' Interaction Analysis. In this procedure, a recorder makes observations of classroom behavior and tallies the behavior according to some classification scheme -- either a *sign system* where only specific behaviors identified in advance are

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recorded, or a *category system*, where it is assumed that all behaviors, regardless of their nature, can be classified in some way. The behavior frequencies are then translated to a matrix (see Figure 1) for subsequent analysis. Typically, the overall observation period does not exceed 20 minutes with tallies being recorded at approximately 3-4 second intervals.

Figure 1
Example of behavior frequency count (left column) translated into behavioral analysis matrix (10 rows X 3 columns)

Behaviors Observed per 3-5 sec			1	2	3
5		1	x	xx	xx
3		2			xxx
4		3	x	x	xx
9		4	xxx	xxx	xxx
4		5		x	xxx
1		6	x		
2		7			xx
4		8	x		xxx
1		9		x	
5		10	xxx		xx

The category system is usually preferred over the sign system because of its dynamic nature and more exhaustive approach to quantifying behavior. Examples of verbal teaching behaviors include reinforcing, questioning, lecturing, and the like. Illustrative examples of student verbal behaviors include initiating, responding, and so on. Behaviors not falling within these general boundaries are said to be indicative of *noise* or *confusion* and are recorded as such.

Depicting Classroom Behavior Via Computer Simulation.

How can computers be used to visually, aurally, interactively, or otherwise, simulate classroom behavior? From a visual perspective, the answer to this question probably lies somewhere between the continuum represented by two-dimensional, stick-figure drawings and virtual space, combined with real-time knowledge systems (i.e., databases). Figure 2-4 illustrates three examples of where points along this continuum might exist.

Three-dimensional virtual reality (VR) constitutes the other end of the continuum and is an environment worth examining for its ability to add visual depth and meaning

Figure 2
Low Fidelity

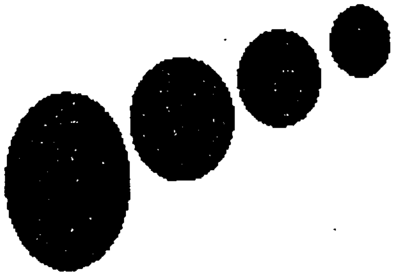

Figure 3
Medium Fidelity

Figure 4
High Fidelity

to simulations. VR offers navigation and three-dimensional viewing of worlds in real time while allowing users to move with six degrees of freedom: forward/back, up/down, left/right, pitch up/down, angle left/right, and rotate left/right (Von Schweber & Von Schweber, 1995). The user's role shifts from being passive to that of becoming involved. As a clone of physical reality, users "exist" in three dimensions, experience reality in real time, and have the ability to interact with imaginary space surrounding them. Whereas interaction type (e.g., "fly-through" versus "reactive") defines a VR experience, level of interfacing (e.g., "through-the-window," "into the room," and "immersive") enhances it.

An ever-increasing number of computerized tools are emerging which offer assistance in building artificial worlds. Different products (*Cyberspace Developer's Kit, World ToolKit for Windows, VR Creator* and the like) support several types and levels of interaction and immersion. Many of these software tools allow linkages to be made between the finished product and external databases -- an essential feature for demonstrating and analyzing classroom behavior via simulation.

Developing a Plan of Action

Research Team. For the purposes of this project it was essential to organize a team of individuals with varying levels of experience and expertise. Toward this end, a core team has been formed and consists of at least one, and sometimes several of the following: computer programmers, instructional designers, videographers, graphic artists, behavioral psychologists, educational researchers, and a project manager.

The role that programmers will play is critical and may appear obvious. Notwithstanding, such individuals must demonstrate mastery-level competency in object oriented languages (e.g., *C++*, *Visual BASIC*, etc.), as well as multimedia authoring environments (e.g., *Authorware, Toolbook,* and *Director*), and three-dimensional animation programs (e.g., *3-D Studio*).

Videographers and graphic artists bring the visual expertise required to guide the selection and/or creation of images used to realistically (or abstractly) represent human behavior. Varying degrees of image realism must be generated in order to make comparisons, etc. aimed at arriving at optimal fidelity levels.

Instructional designers assess needs, design instructional components, propose effective strategies for delivering instruction, and evaluate outcomes of the instruction. The psychologists assists in the quantification of human behavior -- namely, teaching and/or learning. Educational researchers participate in the identification, collection and analysis of data used to create the knowledge base component of the simulation. The project manager serves multiple roles while assuming primary responsibility for scheduling, identifying additional resources, and the like.

Information Resources. A number of electronic databases will be evaluated and utilized to generate the knowledge base for the simulation. Several CDROMs of this type exist and are currently available (e.g., *National Longitudinal Study 1988, Education Statistics*, and the like). Several previous investigations employing older technology will be reviewed to compare methodology, analysis and research findings (Strang, et al., 1991; Strang, et al., 1989; Strang & Booker, 1984; Strang & Booker, 1983).

Developmental Tools. Newer technologies and software products will continuously be reviewed for their capability to provide a programming environment robust enough to complete the project in a timely manner. Where necessary, several products will be combined to achieve results. Hardware is currently limited either to a Pentium-based environment or UNIX workstation. It should be noted that hardware selection is based largely upon availability and current performance ratings and is subject to change at any time.

Time Line. The feasibility of such an undertaking will be evaluated periodically and regularly. As a part of the formative evaluation process, decisions will be made to either proceed with the project as originally planned, alter the current course of action, or abandon the project altogether. Weekly meetings are planned with all participants providing progress reports on any new developments which might benefit their own immediate needs or the team as a whole. If the "green light" to proceed is retained, the team will develop a rapid prototype of the simulation, conduct a pilot test of its functionality, and then move quickly to seek additional funding for expansion of the model.

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