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Games as Teaching Tools: The Computer Connection

Recently video games have been receiving considerable attention in the popular press. Much of what has been written has been emotionally charged and full of rhetoric. Cities have moved to ban certain types of video game establishments. A recent Supreme Court decision failed to overturn a ban on commercial video games in Marshfield, Massachusetts (*InfoWorld*, Dec 26, 1983/Jan 2, 1984). The ban forbids the use of "any mechanical or electronic amusement device, whether coin-operated or not." Home video games and computers are not affected. The implications of such bans are that video games entail much evil and few, if any, compensatory virtues.

Proponents of video games are also marshalling their forces. According to the *InfoWorld* article, David Brooks of the University of Southern California, a participant in the Harvard/Atari May 1983 Conference on Video Games and Human Development, states that "video game arcades do not present a danger to youth, [and] the concerns heard all over the country appear to be based on fear and not on facts." Brooks cites his own survey of 1000 teenagers in which 80 percent spent less than five dollars per week on video games.

In this paper, we side with Brooks, and, in fact, go further. We believe that video games have the potential to be very powerful educational tools. A small part of this potential is currently being realized; much more could be.

We will attempt here to address some of the issues surrounding video games as well as the corollary computer games. After a brief examination of what the games are currently teaching, we will focus on the games' potential for teaching. In conclusion, we will sound a few warnings about the possible negative aspects of video game playing.

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HISTORICAL PERSPECTIVE

The notion of computer games as teaching devices is not new. For more than twenty years computers, in one form or another, have been used as tools of instruction. Computer-assisted instruction (CAI) programs used the computer to teach specific skills and knowledge, such as arithmetic, reading, and foreign-language vocabulary (Suppes, 1966; Atkinson & Wilson, 1968). CAI utilized the interactive nature of computers, making use, for example, of the student's history to determine difficulty level of the to-be-presented material.

However, traditional CAI programs were relatively dull experiences from the pupil's point of view. They lacked the strong motivational factors that are incorporated in current video games. For example, CAI originally used teletype machines devoid of graphics capabilities. Today, in contrast, video games incorporate state-of-the-art vector graphics and laser disc technology to present a very sophisticated visual experience. A great deal of fantasy and role-playing can occur with present-day video arcade games. These factors, among others, have the potential to substantially increase the motivational power of the educational experience.

The present state of video games is similar in many ways to that of early television. Video games are based on a relatively new technology, the microprocessor. The educational potential of this technology is comparable to that of television in the late forties and early fifties. Television began as merely radio with pictures, and borrowed much of its early material from radio shows. However, television never realized its potential; it never became a teaching tool in the traditional sense. Television was, and still is, a strong socializing factor. Television viewers learn a great deal about social norms, fashion, and accepted modes of behavior whether they realize it or not. There are numerous unanswered questions about the social effects of television. How, for example, do adults and children react to television violence?

During the early fifties, there was a research window of approximately five years (Lepper, 1982), a chance for well-controlled experiments that could have addressed both educational and social issues. However, we lost that chance; today television is so pervasive that there are no appropriate control groups of nonviewers.

Video games are facing a similar situation. There are numerous interesting, unanswered questions. The games are not as prevalent as television and suitable control groups are still available. The time to address the question of the effects of video games is now.

THE PRESENT SITUATION

What are video games currently teaching? Most video game manufacturers and video game magazines assert that the games are teaching hand-

eye coordination and are causing a decrease in reaction time to various stimuli. Ideally, such skills could be transferred to other domains, such as athletic ability, marksmanship, piloting an aircraft, or driving a car. Whether such transfer indeed occurs, however, is an open question. The games certainly teach specific game-playing techniques since players do improve their performance on particular games. Certain strategies of offense and defense are developed and tested by the player with the best overall strategy being applied by each individual player.

Other probable forms of learning that occur as people play video games, although somewhat more subtle, may have a greater overall effect on the players. Such covert learning would include the socialization from the game itself. Just as television taught us things about life in general, video games may be teaching players certain things as well. Video games tend to teach players that competition with ourselves and others is healthy and that competition is a trait that should be fostered. Several games also teach that violence is constructive and a proper solution in many situations. A minority of games encourage and teach cooperative behavior. One such game, Joust, is a two-player game in which both players control their own on-screen characters simultaneously. The players have the choice of attacking only the enemy or both the enemy and one another. If the players cooperate, they can earn a special bonus and will generally play longer and obtain higher scores. Thus players who cooperate are rewarded directly, while highly competitive players are punished with less playing time.

Could academic education take place in the video parlors? At present, the general ambience of the arcades is considered inimical rather than conducive to education. This could change, of course. The games within the arcades could be made more overtly educational in response to community pressure (as in the case, for example, of *Professor Pac Man*). But the proposition that people will be willing to pay a quarter to play a game that is primarily educational in nature is dubious at best. Arcade operators might find it more profitable to stay with games that are purely entertaining rather than taking the potential educational benefits of the games into consideration. More likely candidates for the placement of educational video games would be the home and the school.

POTENTIAL OF VIDEO GAMES

What could video games be teaching? Current video games contain two critical ingredients for effective teaching. The first is motivation. All successful video games are highly motivating and reinforcing (Loftus & Loftus, 1983). In order to make players want to continue to play, the games are designed to give rewards at appropriate times. Such reinforcement schedules are part of what makes most games so appealing and addicting.

Current video games involve the player as fighter pilot, race car driver, tank commander, and motorcyclist. These fantasies immerse the player in a normally unattainable but highly enjoyable world.

The second critical ingredient for effective teaching is the interactive capability of video games. Since video games are controlled by computers, they can easily be reprogrammed and fine-tuned. With such flexibility, games can be adjusted to the needs and abilities of each player. Progress of the player can be monitored by the computer, and the player need never become bored with the task if the computer keeps one step ahead.

Given these basic ingredients, there are a variety of educational topics for which video games seem tailor-made:

1. Physical Laws

Traditionally, a physical law is embodied in an abstract equation. A video game turns such an equation—and variations or errors in the equation—into an immediate, true-to-life visual experience. Computers and the video games that they support can be useful in teaching physical laws. The student can gain powerful intuitions about physical laws by observing, for example, the path of objects under various situations.

Consider the current game, *Pinball Construction Set,* which makes use of icons to represent the various parts of a standard pinball machine. The player is allowed to insert and move several parts of the pinball machine to create a video pinball machine from scratch. The number and placement of flippers and targets are left up to the player. Gravity and elasticity of objects can be set to various levels, allowing the player to experiment with several combinations that would be impossible in the real world. For example, with gravity set to a high level, the pinball will drop with amazing speed, and the flippers will seem to have little power to propel the pinball upward. When elasticity is decreased, the pinball will tend to sink into the boundaries and bumpers, thus drastically reducing the overall speed of the game. With such physically impossible situations simulated graphically, the student soon realizes what is correct and what is not. By constantly trying out new hypotheses, the student comes to an ever closer approximation of how the real world operates.

An example of such hypothesis testing might be the plotting of a ball as it is thrown into the air. The student is asked to enter an equation for the path the ball will take. If the equation omits certain factors, such as horizontal velocity and wind resistance, the ball's path, as plotted on the screen, will not appear correct. The student will then find it necessary to make adjustments in the equation. This fine-tuning will continue until the path of the ball appears correct to the student. Using such graphic presentations, a stronger bond between the equations and reality will be formed.

2. Reading Skills

Research is presently being conducted on the use of video arcade style games to teach reading skills (Frederiksen, Warren, Gillote, & Weaver, 1982). Frederiksen's past work has focused on particular subskills, such as automatically recognizing letter groups, necessary in good reading performance. If poor readers are shown to be deficient in any of these areas, appropriate drill and practice can be provided. Such drill and practice are traditionally boring, but video games can inject excitement and interest into the process.

Consider as an illustration the ability to recognize specific letter groups such as *cl, th, ing,* and *ch* as they appear within words. Good readers are able to identify such letter groups more automatically than poor readers. Acquiring such automaticity requires practice (Schneider & Shiffrin, 1977). Automaticity refers to the ability to perform a task without attention or effort. Therefore, it would be desirable to provide the poor reader with a chance to practice recognizing such letter groups. Fredericksen and his colleagues designed a game called Speed to do just that. The student is instructed to watch for a given letter group as words are presented on a television screen. At the top of the screen, the target letter group is displayed throughout the session. As each word is presented, the student is asked to press one key if the target letter group is present in the word and another key if it is not present. The gamelike, motivating, innovation is a speedometer at the bottom of the screen which indicates the overall speed in words per minute. Initially, the words are presented at a relative slow rate of about 80 words per minute. When the student responds correctly, the rate is increased; when the student responds incorrectly, the rate is decreased. The student is given a specific goal in terms of a to-be-achieved speed. As the student improves, the speedometer slowly increases, thereby providing visual feedback. If an error is made, the speedometer slips down a notch and one of five error lights ominously appears; however, after some pre-set number of successive correct responses, one of the error lights disappears. If the player ever has five error lights on, the game ends and the chastized player must start over.

A game like *Speed* involves a specific goal, a constant challenge, and a fantasy vaguely reminiscent of driving a car at ever-increasing speeds. One researcher who has studied this area (Malone, 1980) asserts that challenge and fantasy are necessary conditions for what he terms *intrinsic motivation*. The first step in successful teaching is the motivation of the child toward learning. Any learning situation, claims Malone, requires a specific goal, a difficulty level that is responsive to performance level, and fantasy, if maximal motivation is to exist. These ingredients are clearly evident in most video games, which is what makes them so successful at acquiring our quarters. Our job as educators and psychologists

is to identify and incorporate these features into as many teaching situations as possible to make learning as enjoyable and rewarding as possible.

VIDEO GAMES AND COMPUTER LITERACY

Since all video games are based on computer technology, there exists a potential link between playing video games and using computers. Consider the following, quite plausible scenario. A child becomes attracted to the computer by playing a video game. The child's fear of computers (if any) is reduced by interacting with the machine while playing the video game. As the child becomes more sophisticated, he/she becomes interested in how the game works and wants to learn more about the computer itself. The child may want to learn how to take control of the computer to create his/her own game. This would serve to ease the child into programming. Without the initial attraction of the video game, the child may not have ever expressed an interest in computers.

Certainly not all cases of video game play will lead to a desire to program, just as not all television viewers become electronics experts. But, if only a small percentage of players become programmers, it could be argued that video games have served a useful purpose.

Players need no formal programming knowledge to modify some of the newer home computer games. These video games are highly interactive and allow players to create their own games on the screen. *Lode Runner* is a jumping and climbing game along the lines of *Donkey Kong*, but with an important difference. The player is allowed to create different patterns of ladders and platforms to make the game continually challenging and different. Other programs are available to create Pac Man-like maze games. A program called *Arcade Machine* allows the building of general purpose video games. The player designs the layout of the screen and the shape of the alien monsters. Complex paths for the attacking enemies are plotted. The scoring and general design of the game are both under direct control of the player. The important thing about these games is that they incorporate such programming fundamentals as repetitive loops, if-then conditional branching, and Boolean logic. Familiarity with these concepts facilitates the eventual learning of actual formal programming.

A somewhat less optimistic goal than the teaching of programming might be to raise children as competent computer users. Video games may be an ideal introduction to using the paraphernalia of computers: the keyboard, turning the computer on, using floppy disks, and the myriad of other rituals that the first-time computer user must learn. The coming generation of computer users may want to utilize the computer as a tool or simply as just another appliance. This generation of user will only need to be able to use prepared programs such as word processors, spreadsheets,

and data-base managers. Once children become comfortable with using the computer to play video games, they will find it easier to move on to more serious uses of the computer.

OTHER COMPUTER GAMES AS TEACHING TOOLS

Video games are only one type of computer game. There are several different types of computer games, each with its own unique, teaching capabilities. One popular form is the adventure game. There are many types of adventure games, all of which derive from the original mainframe computer game, *Adventure*, created by Crowther and Woods at MIT. In adventure games, the player is presented with verbal descriptions of his/her surroundings and moves around by typing directional commands to the computer. The player generally has a specific goal, such as saving a princess or slaying a dragon. Along the way the player is required to solve a series of puzzles or problems. For example, a player comes across a locked door. After peering into the keyhole, the player's view is obstructed by a key inserted in the opposite side of the keyhole. The only tools available are a place mat and a letter opener. The solution is to insert the place mat halfway under the door, use the letter opener to dislodge the key from the keyhole, and gently pull the place mat from under the door with the key lying on top. Most adventures are riddled with such ingenious puzzles.

Several current adventure games allow the player to enter entire sentences and even multiple sentences, which the game then parses and acts upon. Such games can be used to teach a variety of subjects. At a basic level these games teach reading and verbal communication skills, since the player is required to converse with the computer in order to get a specific point across. The player must carefully read the textual description for hidden clues in order to solve the puzzles. The overall enjoyment value of such games may induce students to increase the amount of time spent reading. A topic, such as mythology, may be introduced within the context of an adventure game. The student will then be motivated to read other sources for vital information to the completion of the adventure game.

Adventure games also teach map-making skills and spatial relationships, since the player needs to remember the layout of the particular adventure. Logical thinking and problem-solving ability are required to successfully complete many adventures. Adventure-type games need not be entirely text oriented. With the incorporation of high-resolution pictures into many adventures, educators can devise adventures which pair pictures with words within a story to teach reading skills for beginning readers. For example, each object that the player comes across could be

presented on-screen graphically, along with a written description. Such pictorial adventures would directly involve the player's visual and spatial skills. Compared to the current mode of teaching reading, these adventures might increase the motivation and attention of the average first grader. The interactive nature of these games would increase the child's involvement with the material, while serving to keep the process fresh.

An outgrowth of adventure games is interactive fiction. Here the reader makes decisions at critical points in a story that directly affect the outcome. Thus, the reader is able to control the story's development. Consider, for example, the murder mystery: The reader is allowed to follow specific leads, trail suspects, assemble evidence, and, hopefully, apprehend the guilty culprit. Who has ever read a book and wanted to change certain parts in order to see what would have happened to the characters? Such interactive fiction injects new excitement into reading for students who view current forms of reading as passive and dull.

Another popular type of computer game involves simulation of some real-world endeavor. Simulation games teach certain skills either covertly or overtly. In contrast to adventure games, which teach general reading skills and problem solving, simulation games provide knowledge about specialized topics. Business simulations (e.g., *Millionaire, Cartels and Cutthroats*) teach theories of economics. They stress the importance of money management in successfully running a business. Such simulations are an ideal way to teach sound business principles without risking anyone's money. Investments can be shown to grow or dwindle over time (often quite graphically) within a matter of hours, not years. The player is presented with plotted graphs of profit/loss curves and quickly learns how to read a profit and loss statement. Critical decisions can be made and tested before those same situations arise in real life.

Election simulations teach political science covertly. *President Elect*, for example, teaches how the electoral college works. The game presents a complete map of the United States, utilizing color to indicate which candidate is ahead in each state. The campaign lasts nine weeks, and the constant flow of candidates' fortunes is presented to the player. The player's job is to allocate time and money to national, regional, and state campaigning. Such simulations could be used to instill interest in the overall election process.

Flight simulators allow the player to learn some basics of flying an airplane. The player can choose from several types of planes, from World War I biplanes to jet fighters. The aerodynamics of flight are taught without the player's realization that learning is occurring. Similar simulations could also be developed to teach good automobile driving habits. These simulations are useful teaching tools with no cost or risk of injury to the student.

War game simulations, although disliked by many, still may serve use-

ful purposes. They teach the realities of war by translating the numbers into something tangible for the child. With maps of countries showing the destruction and devastation, a child soon realizes the utter futility of war. If the player decides to enter into a war, the outcome of such a decision can be displayed to the player immediately in rather graphic terms. Such games, however, could lead to a desensitization of war if not handled properly. Discussions should be led by parents and teachers as the child makes critical decisions. The game can be used as a springboard for future discussion and debate. Just as the television screening of the film *The Day After* was followed by mock war-room discussions, students can use war simulations to measure the direct effects of such actions as using nuclear weapons in future wars. This, of course, raises the issue of reality versus fantasy. There is a strong need to teach children the differences between the two, and these simulations could serve as the starting point for teaching such differences.

SOME FINAL WARNINGS

Not everyone shares the view that incorporating such embellishments as fantasy and graphics will increase the overall quality of the educational process. Lepper (1982), who seems to be generally in favor of video games, has sounded a warning to those who see the computer as a panacea for all of education's current problems. He feels that the addition of such motivational features as fantasy, plots, graphics, and sound effects may have certain detrimental effects on the learning process. They may distract from the task at hand, rather than enhance the learning process. At the very least, Lepper, asserts, such additional material will lead to less learning per unit time as the learning situation becomes more elaborate.

Lepper is further concerned that boys vastly outnumber girls in video arcade parlors and that, to the extent that computer games lead to computer literacy, such an imbalance may lead to fewer girls developing programming skills. Lepper also cites class differences in access to computers and questions whether video parlors might serve to equalize this discrepancy. These are all serious issues and, as Lepper points out, we have a very limited time in which to investigate them. We have a research window of perhaps ten years in which to conduct research before computers become as widespread as television is today. If the research is not conducted now, while suitable control groups are available, all chance of answering these questions may be lost.

As researchers, we should not let video games and computers go the way of television. Psychologists lost their opportunity to study television with well-controlled experiments. Today television is merely being moni-

tored to reduce any harmful effects on viewers. Such groups as the Moral Majority are simply trying to reduce the amount of violence and sex on television. Other groups are attempting to reduce the amount of racial and sexual stereotyping present in several television programs. In its developing stages, television was never directed to teach positive social norms and was allowed to develop in a haphazard manner. We have a chance to correct and avoid these mistakes with the developing technology of video games and computers.

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