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SESSION XII EDUCATION

Computers and education

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The rapidly diminishing size and cost of computers and their increasing use in new areas is taking both psychologists and on-line computing outside the traditional laboratory. One of the most important areas for psychologists' involvement is in education, both as traditionally described in formal settings and in uncharted, new formats outside schools. This includes preschool toys, arcades, games for older children, and new computer parks like Sesame Place in Philadelphia or Capital Children's Museum in Washington. After a description of these educational computing contexts, a brief discussion will be provided of the implementation of some of these ideas with a young child.

Only a few years ago, few of us would have dreamed of a computer in every school; yet, that dream is almost a reality today (National Center for Educational Statistics, Note 1), and we can begin dreaming of a computer in every student's pocket. This dramatic hardware change is being followed much more slowly by software changes, and increasingly it is creating major emphasis on decisions about how to implement the hardware. The main problems and obstacles to computers in classrooms are shifting rapidly from engineering hardware to writing software.

It seems unquestionable that psychologists will play an intensive role in defining the criteria and evidence that will constrain these decisions. It seems equally clear that these psychologists will come from every major division of our discipline–cognitive, developmental, educational, and social–all unified by a common interest in computers and their best application to teaching and learning.

In this paper, I will examine more closely the direct instructional use of computers, beginning with a contrast between computer literacy and computer-aided instruction.

COMPUTER LITERACY AND COMPUTER-BASED INSTRUCTION

Computer literacy is a popular term, and many educational researchers are deeply involved in research on it (Kirschner, 1981); yet, the term escapes precise definition. It seems almost negative in its definition: those uses of computers in classrooms that are not part of the standard curriculum. This includes learning to program and learning about the hardware, as well as playing arcade games, using simulations, setting up communications with large data bases or other students, and several other activities.

Computer literacy exists in negative definition particularly in contrast with computer-based instruction in its many forms. Computer-based instruction is almost as badly in need of definition, so I will begin with an attempt at a taxonomy that ranges from drill and practice and information display to interactive games and attempts to use the computer as a tutor. The taxonomy attempts to be dimensional along a line from passive to interactive, but there are obvious clear limits to this dimensionality: Drill and practice, for instance, can be made in combination with diagnostic, on-line tests that assess the internal coherence of errors and provide remedial practice in ways that are as interactive as any Socratic tutorial. It is not clear how useful this taxonomy is, given this basic limitation, but it provides a rough ordering of currently available courseware.

DRILL AND PRACTICE

Drill and practice software for education encompasses more programs than any other. In mathematics, particularly, this popular format covers topics such as integers, fractions, decimals, percentages, primes, geometry, algebra, trigonometry, calculus, and statistics, almost a full curriculum. Science areas are much more fragmentary and deal to a larger extent with high school topics, rather than introductory and elementary subjects. English, on the other hand, is thoroughly covered across its range from letters and sounds to writing, spelling, and comprehension in reading. Other topics

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for which computer materials are available include geography, history, music, health, law, and foreign languages. At a postsecondary level, many more topics are covered.

INFORMATION DISPLAY

In another use, the computer is a page turner, providing displayed text and prerecorded voice instruction that follows a written (and often preexisting) textbook almost perfectly. As deadly dull as you might think this is (and it often is, especially on a low-resolution, flickering, color CRT), this is probably the next most frequent format. Many book publishers, eager to rush into this expanding computer market with a maximal investment, realistically see this as the only economically feasible course of action.

GAMES AND SIMULATIONS

Another format tries to make education more exciting by using games and simulations. Simulations are very rare, and so far, they have not been too successful or effective, so I will focus my attention on games. When these games are taken from activities that outstanding teachers normally use in a classroom, they are justifiable, useful, and instructive, particularly for repetitive practice of some essential skills. But all too often, the game format is used in an arbitrary way based on a superficial analysis that says it makes learning more appealing and motivated. Malone's (Note 2) article titled "What makes things fun to learn?" seems to have provided a superficial stimulus to an already popular notion that computer games (particularly fantasy games) are especially and intrinsically motivating. Basically, I think that this argument is not very compelling and has a limited application to any serious educational setting.

Let me be a curmudgeon about this and try to make my point in a very weak way: weak because I will choose an example that in many respects is a really good instance of the use of a game for instruction. Sharon Dugdale at the University of Illinois (cf. Dugdale & Kibbey, Note 3) has created an instructional game (informally called "green globs") that has attracted the attention of students and researchers (cf. Feurzeig, Horwitz, & Nickerson, Note 4; Malone & Levin, Note 5). A dozen green dots are displayed randomly on a microcomputer, and a student's task is to write the equations of the fewest functions that will go through all of the green globs. There is an ingenious use of a library of outstanding games and a hall of fame of the names of high-scoring individuals (which Lesgold, 1982, intriguingly reports are often pseudonyms). The general consensus is that students do enjoy the game and seem to learn some algebra from it.

In the face of such a positive assessment of the game, it may seem trivial to criticize the use of games in education. But my argument is that games have only a limited use because a game is not an effective instructional tool. This response comes from introspections about using the "green globs" game. When I was learning algebra, I would much rather have had a much simpler and more convenient way for systematically graphing circles, ellipses, parabolas, hyperbolas, and so on, to see what effects changes in constants, first derivatives, and exponents had on the shapes. The game aspects of "green globs" would have interfered with a coherent and systematic exploration of these effects: It would have interfered with efficient learning. This seems to be a general characteristic of games. As in the spelling bee, games might be better used to demonstrate that learning has taken place than to create learning. After all, if one examines present-day instruction in schools, one finds very few games, except for the drill and practice of tedious things. Teaching is a serious business, and I can find no compelling reasons why computers should change that state of affairs; but, perhaps I am just an inveterate dedicated learner.

THE COMPUTER AS TUTOR

Finally, I complete the taxonomy of computer-based instruction formats with the rarest form of all, the tutorial. It is rare because the multiple branching and feedback loops needed to carry it out effectively require a fairly large and fast machine, even when restricted to relatively tiny educational domains like subtraction in Brown and Burton's (1978) BUGGY programs. They are also rare because they require an immense increase in our codified (rather than intuitive) knowledge in these educational domains. We need answers to many questions. What do good teachers do when they teach so effectively? What are the principles that govern their ordering of the material, the kinds of questions they ask, the examples they use, the answers they give, and the metaphors and hypotheses they generate? Another domain extends through the structure of knowledge in students' minds: How does this knowledge grow and develop? What errors in thinking are stages and more or less necessary to pass through to reach sophisticated states of knowledge? What are the best ways of describing the structure of this knowledge? A further domain that needs to be better understood surrounds the computer hardware: What sorts of input/output devices are needed and how should they be used? What kinds of languages are needed to create the courseware? How can materials be made transportable and deliverable on many different machines? How can continuing changes in the hardware be accommodated? These hardware problems are common to all uses of the computer in education, but they are particularly difficult to surmount with more complex materials like tutorial courseware.

PRACTICAL PROBLEMS

Courses that try to teach computer literacy and those that deal with a more standard curriculum do not have equal status in the eyes of the educational community (Kirschner, 1981). Computer literacy appears to be seen more universally as a requirement, something all students need to be taught at some point in their careers. Certainly, computer manufacturers and sellers appear to agree. The materials they produce to teach programming seem much more innovative, with interactive problem solving and diagnostic routines that are considerably more complex and interesting than the regular courseware offered on the same machines.

Using computers to teach a standard curriculum seems much more uncertain and fraught with difficulties. Teachers have little formal training to deal with computers. The materials to teach courses at all levels are not particularly interesting. There are fears that computers will replace teachers. In some instances, budget cuts have already replaced staff with computers. In this era of scarce money, it is not clear who will pay for the hardware and software and it is even more difficult to say who will pay for the research that is needed to improve the quality of courseware and computers in education (Melmed, Note 6).

NATIONAL INSTITUTE OF EDUCATION DEMONSTRATION CENTER

We have set up a demonstration center at the National Institute of Education for different kinds of courseware. We plan to examine interesting programs, show them to visiting dignitaries and teachers, and broaden our own understanding of what is possible. I will be happy to receive any interesting examples for examination and display. Contributions will, of course, be protected from duplication and unauthorized use.

PRESCHOOL AND OUT OF SCHOOL

One of the clearest effects that computers are likely to have is to extend formal education to earlier years and to homework. Computer data bases and local networks of microcomputers are already beginning to affect homework (Hunter, Note 7). Hundreds of games and electronic learning aids are introducing children to reading, writing, computation, and general intellectual skills. These activities are clearly expanding toward full-scale information processing.

My thinking on this topic is undoubtedly biased by my special interests. I have a 2-year-old son whose interest in computing is being awakened. I have written a number of simple programs for him to use. My interests have centered on pattern matching: random matrices of dots that can be chosen from four alternatives on the basis of such things as one of the symmetries, the density of the dots, or local differences in the random structure of the visual displays. My 2-year-old interacts with these programs periodically and appears to enjoy these somewhat dull-sounding experimental tasks. But for most programs, his performance is still nearly random. Simple geometric form classification and letter matching on the keyboard are his favorite activities. Games like these seem very appropriate for children. Computer displays, with their movement and easy ability to be controlled precisely by simple keyboard entries, seem to fascinate him in ways that other toys and books do not.

His favorite program is one in which large, oversized letters walk out on the display, stop, and wait for him to press the appropriate key; then they ride out on the flatcar of a train. Now that he has memorized the keyboard, his interest has not diminished much. He presses the proper keys to stop and start the train in its progress. These keys are not part of the program, but part of the BASIC monitoring system on the TRS-80. (Copies of this program for a 16-KB Level II TRS-80 are available on request.)

Educational activities for preschoolers in general have barely begun to be tapped. For instance, LOGO is not yet widely available and certainly has not been properly interfaced for very young children (Abelson, Note 8). I suspect that there are many other researchers creating code for their children, and I hope that these programs are shared so that computers can be fully developed for children and education.

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