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ABSTRACT

This report summarizes the proceedings of a conference held at the Harvard Graduate School of Education which focused on the conceptual distinction between microworld software and expert system software in education. Microworld software is defined as software which lacks a specific teaching and learning agenda, and expert systems as software that comes with built-in knowledge of a domain and a built-in plan of instruction in that domain. To assist program presenters in examining the design polarities implied in the two systems, two pairs of educational software systems (carefully chosen to illustrate the polarity) were displayed and discussed. These systems--The LISP Tutor and Geometric Supposer on the one hand and The Writer's Workbench and Quill on the other, provided the basis for subsequent presentations and panel discussion. Presenters noted specific design and utilization differences between Geometric Supporter and LISP tutor: the former is a tool which students may use in an exploratory fashion and the latter makes inferences about a user's intentions at each step of a guided path. Workbench differs from Quill in that that the former, with its original design as an editing tool with explicit technical analysis, precludes its judging the writing product itself, while the latter is designed to help generate writing materials and facilitate writing between student and teacher, or among students. A more in-depth presentation of each of the four systems, along with the presenter's comments on its use and applications, follows the initial comparison of the systems, and closing remarks suggest that the concepts of both types of system should be utilized in an educational environment. (JB)

Microworlds and Expert Systems:

Is It Either or Can It Be Both?

Conference Report

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On January 11 and 12, 1985, the Educational Technology Center sponsored a conference entitled "Microworlds and Expert Systems: Is It Either or Can It Be Both?" Held at the Harvard Graduate School of Education, the conference attracted approximately 150 elementary and secondary teachers and other educators, as well as researchers and software developers from New England, other states, and Canada. The opening session, an evening one, was devoted to registration, informal conversation among conferees, and opportunities to examine two pairs of educational software systems, each pair carefully chosen to illustrate the design polarity implied in the conference's title question. These systems -- The LISP Tutor and Geometric Supposer on the one hand, and the Writer's Workbench and Quill on the other -- then provided the focus for the next day's presentations and panel discussions. [The LISP Tutor, Advanced Computer Tutoring, Inc., Pittsburgh; Geometric Supposer, Sunburst Communications, Pleasantville, N.Y.; UNIX Writer's Workbench, Bell Laboratories, Murray Hill, N.J.; Quill, DCH Educational Software, Lexington, Ma.]

The conceptual distinction at the heart of this conference between microworld software and expert system software in education is based on the notion that the first lacks and the second embeds what might be called a specific teaching and learning agenda, based on an explicit paradigm. Thus, for example, the Geometric Supposer is a tool which both geometry teacher and geometry student may use in a highly exploratory, undirected fashion, or in some fashion uniquely tailored to a specific situation. Like microworld software in general, as ETC Co-director Judah Schwartz put it, it is no "smarter" than whoever uses it. The LISP Tutor, on the other hand, is built according to its designers' model of an efficient sequence for learning LISP, a programming language associated with artificial intelligence. Thus it comes with built-in knowledge of a domain and a built-in plan for instruction in that domain. Unlike microworld software, it makes inferences about a user's intentions at each step of a guided path to a preconceived goal, namely mastery of LISP. Analagously, Writer's Workbench offers its users explicit technical analysis of their writing samples based on preconceived notions of what constitutes good prose and of the kind of help an aspiring writer needs to achieve it. By contrast, Quill provides student writers with various opportunities to write and edit, and it provides their teachers with opportunities to intervene in both these processes; yet it prescribes no standard by which to judge the results.

The "smart" tutoring of a LISP Tutor or of a Workbench is a mark of our progress both in understanding cognitive psychology, and in designing knowledge-based systems; together, these advances offer great promise of educational application. But so too the sophistication of the tool-like Supposer and Quill is a harbinger of great educational possibilities. One theme of several conference presentations was that we ought to consider the future of these educational technologies not simply from a technical perspective -- that is, what can we design? -- but from

a moral perspective as well -- what should we design? This last question in turn suggests some others: What is the likely impact of particular changes in how we allocate authority and responsibility among learners, teachers, and computers? How might such changes alter current mores in learning, teaching, schools, or society? Finally, given such likely effects, how should we act now in developing and purchasing educational software?

Lawrence T. Frase of Bell Laboratories, developer of The Writer's Workbench, opened the language arts portion of the Conference presentations with descriptions of the various programs that constitute this software system, and of the concepts of good writing that undergird it. He illustrated, for example, its subset of programs which proofread documents for errors in spelling, punctuation, and certain usage areas, and which search for common diction problems. He also described the system's style analysis programs which provide authors with information considered relevant to the achievement of good style -- like average length of a text's words and sentences, distribution of sentence lengths, percentage of verbs in the passive voice, etc. Finally, Frase discussed the system's capacity to check on text abstractness, to highlight text organization, and even to measure new texts against various "standard" texts judged excellent for particular purposes and audiences.

Although Writer's Workbench was originally designed as an editing tool, Frase here considered its teaching potential too. He took great care, however, to portray the system as informer not prescriber. The writers who use this expert system, he insisted, do so without surrendering any power over their work.

Andee Rubin of Bolt, Beranek & Newman, developers and publishers of Quill, spoke immediately after Frase, and described Quill's four programs. In addition to a word processor called the "Writer's Assistant", these include a "Planner", which student or teacher may use to help generate writing material and angles; a "Mailbag" designed to facilitate writing between teacher and student or among students; and a "Library", or text storage and retrieval program. Rubin emphasized the adaptability of these programs to different teaching styles and objectives, saying at one point, "We wanted to create a piece of software that, far from being teacher-proof, is teacher-dependent." She acknowledged, however, Quill's close association with what she called the "writing process" method of teaching writing [See Donald H. Graves, Writing: Teachers and Children at Work, Portsmouth, N.H.: Heinemann Educational Books, 1983.] In fact, she described the four programs as corresponding roughly to key elements in this approach: engaging students in pre-writing activities, encouraging them to redraft, asking them to share their writing with a peer audience, and using folders to maintain a record of their progress as writers.

To begin the commentary on both morning presentations, Carol

Chomsky, of the Harvard Graduate School of Education, distinguished the two pieces of writing software in terms of their judgmental status, reminding the conferees of one aspect of the microworld/expert system distinction. In these terms, Quill does not judge the writing product, while Writer's Workbench does. And insofar as it does, Chomsky pointed out, it introduces a new dimension into writing instruction, namely the possibility of feedback from some source other than teacher or peers. This raises, in turn, she added, questions about the degree of authority we wish for this new commentator, and the standards we want its authority steeped in. On the other hand, Chomsky continued, although Quill, in dealing with process more than product, seems less judgmental than Workbench, it nevertheless enters the writer's experience at a much earlier point, and this fact alone may have important consequences for student writers.

Harvard's Courtney Cazden, the next commentator, pointed out one of these consequences in a case study she entitled "The Story of One Piece of Writing". Its author was Ruiz, a sixth grader, and its subject a trip to the circus. Ruiz's teacher was using Quill in her classroom at the time of his circus composition, and Quill's power to facilitate both her response to Ruiz's writing in progress and his redrafting played an important shaping role in his composing work. These Quill features are designed to provide on the one hand the access to expert knowledge, and on the other hand, the practice which Cazden feels are the two things most apt to drive students' writing efforts toward improvement. Ruiz's teacher clearly used them to do just that. Yet in the end, after having produced a revised circus essay that by objective standards much excelled his first version, Ruiz told Cazden that he preferred his first draft. Cazden's account of Ruiz's experience provided the conferees a dramatic glimpse of the power of Quill's learning environment both to suggest new standards and to drive students to reach them; and his expressed preference for his first draft, captured on tape in his own voice and played for the conferees, provided them also a sense of the moral context in which such pedagogical power is always embedded.

The LISP Tutor was presented by John Anderson of Carnegie-Mellon University, who demonstrated in detail how it works by following the progress of a hypothetical tutee solving problems while guided by the program's hints and corrections. Anderson described the software as embodying "a production system model of the ideal student" and knowledge about "the various bugs" that beset such a student's less than ideal counterparts. He claimed that this knowledge of both efficient learning patterns and of inefficient ones, combined as it is in the program with a capacity for providing quick corrective responses, gives the Tutor greater teaching power and better teaching results than one might expect from a typical classroom situation. He reported on a study of the system's instructional effectiveness which found that only a human tutor can do better that a LISP Tutor in teaching LISP. "We aspire to do better than

human tutors," Anderson added, "but we're not really there yet."

Anderson finished his presentation with what was decidedly a maverick suggestion in a conference dominated largely by a moral perspective. He suggested that the conference's title question -- "Is it Either or Can It Be Both?" -- may in fact not lie beyond the power of science to determine. He called for systematic analysis of the "cognitive effectiveness" of each approach.

The Geometric Supposer , according to its co-authorJudah Schwartz, the next conference presenter, was designed so as "not to conflict with anybody's notion of curricular content in geometry" -- a sharp contrast to the one-best curriculum notion inherent both in the LISP Tutor approach, and in Anderson's concluding comment. That is not to say, however, that the Supposer is wholly neutral pedagogically. It was also designed, according to Schwartz, so as to give its users access to what he called "the soul of making mathematics", namely the creation and exploration of conjectures. In effect, the program enables geometry students and their teachers to become geometricians, to fashion and test geometric conjectures across a variety of instances. To support his sense of the importance of the software's contribution in this respect, Schwartz drew an analogy between instruction in writing and instruction in geometry. We no longer think it wise, he said, to teach students to write merely by having them copy other people's compositions; we now like to give them practice too in creating their own. The same ought to be true in geometry, he concluded.

The Supposer's options permit the user to make constructions of any kind on triangles and quadrilaterals. The user can then direct the program to repeat these constructions on specified or random, similar or dissimilar figures in order to explore any hypotheses he or she may devise as a result of this analysis. Schwartz emphasized the novelty of the repeat function: "Everybody has been fooled by a diagram in geometry into thinking that something was true when it was in fact true about that diagram only. . . . The Supposer makes it possible to explore whatever it is that one is doing in any particular instance across a wide selection of cases of which that instance is just one example."

Another, more subtle benefit of The Supposer on students' geometry learning, according to Schwartz, is its power to suggest the need for proof. Students who use the software, he said, are confronted with the fact that all the discoveries they make as they explore one figure after another are particular discoveries, and "that as long a list of particular discoveries you have, it is not long enough," because generalizability derives from a different dimension of effort.

In turning directly to the conference theme, Schwartz said he can imagine the use of The Supposer within a geometry tutor that does for geometry what the LISP Tutor does for LISP. He

does not, he said, think it appropriate to favor in all cases either expert-system or microworld pedagogy.

In elaborating and supporting this last thought, one of the respondents to this panel, David Perkins of Harvard University, redefined the expert system/microworld distinction as a distinction between channeling and providing conveniences. As such, he claimed, it is the basis of a pedagogical dilemma far broader than it may seem at first, that is, broader than a mere question of software design. He laid out this dilemma for the conferees in two questions: On the one hand, does the convenience of a microworld have power in and of itself to draw the student to learn? On the other hand, does the channeling inherent in tutoring enable the amount of exploration necessary to full learning? He suggested that the answer to both these questions is <u>no.</u> One can perfectly well equip an educational environment with both tutoring and channeling, Perkins concluded, and the research suggests, he added, that one should.