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ABSTRACT

This report of a 1984 conference on the computer as a teaching tool provides summaries of presentations on the role of the computer in the teaching of science, mathematics, computer literacy, and language arts. Analyses of themes emerging from the conference are then presented under four headings: (1) The Computer and the Curriculum (the computer keeps learning connected to experience; the computer provides access to the underlying disciplines of subjects; the computer challenges the curricular status quo; and the computer aids implementation of the curriculum); (2) The Computer and Reality (computer-based models and simulations only imperfectly represent reality; a program may mask operations that students should experience to give depth and stability to their learning; and computers sometimes need to be used in conjunction with other, more concrete, experiences); (3) Perspectives on Teaching Practice (teaching is rooted in a teacher's own interests, need to understand, and social commitment; and teaching is, to a significant extent, a product of circumstance, not an entirely rational enterprise); and (4) Teachers' Professional Development (strategies and goals are needed for teacher training). The report concludes with a list of questions for further research. (11 references) (MES)

THE COMPUTER AS A TEACHING TOOL PROMISING PRACTICES

Conference Report

April 1985

Educational Technology Center
Harvard Graduate School of Education
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On July 12 and July 13, 1984, the Educational Technology Center and the Education Collaborative of Greater Boston (EdCo) co-sponsored a conference entitled "The Computer as a Teaching Tool: Promising Practices." Approximately 150 teachers and other educators from New England and New York braved the hot, humid interior of Harvard's Longfellow Hall to hear four panels focused on several current and encouraging applications of the microcomputer to teaching in math, science, computing, and language arts. Despite the climactic conditions, these participants joined energetically in the discussions that followed each panel.

The format of the conference was novel in two respects. First, the conferees stayed together in one group throughout the presentations and discussions. Thus, despite the agenda's focus on separate disciplines, the themes and tone of the proceedings stayed cross-cutting. Second, the panels reversed tradition by focusing first on practice rather than on theory, with teachers from each subject field presenting case studies of computer applications they had tried in their own teaching. Thus the commentary which followed each pair of case studies -- provided by scholars in the field, educational researchers, and other teachers -- was not the customary effort to derive implications for practice, but rather an effort to situate practice within a theoretical framework. The implicit effect was to accord practice a more valued status, and also to highlight the fact that often practice may precede theory in significant respects. In one sense, the conference was an effort to accomodate theory to practice, to begin to fashion good theoretical perspectives by which to account for the inspirations, disappointments, and general stumblings in the dark that now constitute the experience of many teachers who have brought microcomputers into their classrooms. In a larger sense, it was an effort to find some theoretical basis upon which we might begin to solve the great looming practical problem that ETC Assistant Director Stone Wiske called "the one which lies beyond the introduction of computers into schools -- the problem of how to integrate them into learning and teaching."

Wiske introduced the conference, and her introduction emphasized the commitment of the Educational Technology Center to research grounded in classroom practice. In recounting the efforts that spurred the convening of the conference, she said, "We wanted to sponsor a conference anchored in examples of exciting practices which had actually been tried, not just thought out as good ideas." But she distinguished this from any attempt to present what might be called a showcase of practice. The teachers about to describe their work would not provide "recipes to be concocted in other classrooms", she warned, but rather "visions of possibilities". The value of the presentations, she suggested, would lie in the questions they provoked.

SUMMARIES OF THE PRESENTATIONS

Science

The evening panel on the 12th was devoted to the role of the computer in the teaching of science. Presenters were Bill Read, elementary science specialist, Lexington (Mass.) Public Schools, and John Samp, science teacher, Cambridge Rindge and Latin High School, Cambridge (Mass.) Public Schools. Commentary was by Hal Abelson of MIT, and Judah Schwartz of MIT and the Educational Technology Center.

Read's presentation described his effort to teach some of the concepts in the physics of space flight to second graders, employing among other teaching strategies an experience with software called Dynaturtle [Window, Inc., 1983]. Dynaturtle is a set of logo-based programs. The program Read used in his lesson requires students to maneuver a moving chevron through a maze by keying in a directional "force": forward or backward, left or right. The challenge derives from the fact that this chevron's "inertia" is unimpeded by "friction". To move it in a different direction, as with an object in outer space, one must take into account its prevailing motion. Read's presentation might have been subtitled, "The Building of an Elementary Science Lesson" in that it offered glimpses of the thinking and planning processes that underlie such lessons. In this respect, it contributed substantially to the development of an important conference theme, namely the accomodation of the computer to the dynamics of common teaching practice. It contributed as well to the development of several other themes.

Samp's case study was entitled, "Using a Thermistor and Microcomputer to Study Concepts of Heat and Temperature with High School Students". Duplicating the design efforts of Robert Tinker, at TERC, Inc., Cambridge, Mass., and anticipating the research of ETC's Heat and Temperature Project, Samp had fashioned an immersible thermistor (temperature-dependent resistor), had connected it to his classroom Apple II Plus through the latter's game port, and had written a program to record temperature changes as a function of time in a graphic screen display. In his presentation, he described his teaching experience with this homemade peripheral, and he also explicitly described some of the constraints that ordinary teaching conditions impose on attempts to use the microcomputer in the classroom.

Abelson's and Schwartz's commentary on these presentations focused attention on the genre of computer application each teacher had illustrated. Read, for example, had used "microworld" software, or software which provides an environment that learners may explore according to their own agenda. He had chosen, however, to situate his students' microworld experience within what he called the less abstract context of space flight. Both commentators questioned the psychological appropriateness of this connection, and thereby opened up an important conference theme having to do with potential problems arising from the use of the classroom computer to mimic nature. Schwartz drew a sharp distinction, however, between mimicking nature with the computer, and using it to improve students' access to natural phenomena.

Mathematics

The first of the morning panels began with Jon Choate's presentation. Choate, chairman of the mathematics department at the Groton School, Groton, Mass., described his efforts to teach his students mathematical modeling. He used Visicalc, a spreadsheet program [VisiCorp, San Jose, Ca., 1983], and Micro-Dynamo [Addison-Wesley, Reading, Ma., 1983], a software package which is based on the modeling language DYNAMO and employs a problem analysis technique called system dynamics. The objectives of Choate's teaching experiment, as he explained in his presentation, lay on two levels. First, he wanted to expand his students' experience with problem formulation, to give them practice grappling with the ambiguity and complexity of problems derived from life settings, and to introduce them to the mathematics of change without involving the calculus. Then on a deeper level, he wanted to help these students use mathematics to uncover what he called the beauty below the surface of everyday experience, and to make a contribution to the solution of some of the world's problems. So, for example, he taught his students to use the statistical powers of the spreadsheet to fathom the complexities of situations described in current newspaper stories and to see the simpler patterns at their core; and he taught the students how to use system dynamics to analyze and to talk about social problems like drug and alcohol abuse.

Following Choate, Richard Houde, math teacher and department head at Weston (Mass.) High School, discussed his recent experiment in basing a geometry course on the use of software called The Geometric Supposer [Sunburst Communications, Pleasantville, N.Y., 1985]. The Supposer's options provide the means for geometry students to construct triangles and quadrilaterals as well as altitudes, medians, angle bisectors, perpindiculars, perpendicular bisectors, mid-segments, and parallels. Students can also measure segments and angles, measure perimeters and areas, label the intersections of segments, place points at random, and sub-divide segments into sections of equal length. Finally, the program enables them to repeat any construction they have devised for a single figure on other specified or random, similar or dissimilar figures. In effect, the program enables geometry students to become geometricians, to fashion their own conjectures and to test these conjectures across a variety of instances.

Unlike the teachers whose conference presentations preceded his, Houde had managed a dramatic integration of technology and curriculum, and in a subject quite constricted by traditions of content and method. Thus his presentation offered insight into the consequences of such major technological intervention on teaching methods, curriculum coverage, class management, and students' confidence and mastery of subject.

The commentators for the mathematics panel were Patricia Davidson of the University of Massachusetts at Boston, and Susan Freel of Lesley College. In what was perhaps the best execution of the conference strategy, each focused her commentary on one of the two stories from practice, but used the story largely as a point of departure for an exploration of the theoretical territory in which she thought it lay. So, for example, Davidson viewed the Supposer against the backdrop of the VanHiele [1958] levels of learning in geometry, and viewed Houde's work with it as exemplary of an attitude toward mathematics teaching as problem posing, an attitude she endorsed with enthusiasm. Freel's commentary examined the goal of this teaching as problem posing: what she called "what-if thinking". She found in Choate's modeling and in modeling work generally the perfect environment within which to induce such an experimental and quintessentially mathematical habit of mind.

Computing

Alan November of Lexington (Mass.) High School, opened the panel on the teaching of computing with a presentation on his experience teaching "applications" programs to low-skilled students in a computer literacy class. He called his general approach to the teaching of computing irreverent in its avoidance of some common topics -- flowcharting and how the computer works, for example -- and in its substitution of "business" programs for "educational" ones (Visicalc, PFS File, PFS Write, etc.) [PFS integrated programs, Software Publishing Corp., Mountain View, Ca., 1983]. His purpose in teaching the computer, he said, is to teach his students how it may be used to enhance their personal power and their sense of connection with their community. In describing a project his class undertook to produce a computerized data base directory of services for handicapped people in Greater Boston, November contributed substantially to the development of a conference theme having to do with what spurs the work of teaching. And in sharing vividly an image he has of the computer's power to transform conventional classroom teaching, he contributed to several other conference themes as well.

Paul Goldenburg of Lincoln-Sudbury (Mass.) High School spoke next. In the process, he illustrated fluency in teaching with the microcomputer. This illustration was in the casualness with which he handled a booting-up snafu without engaging in machine anxiety; in the dexterity with which he acknowledged and corrected little keyboarding errors; and in his keyboarding flair, including the use of keystroke sounds to punctuate his delivery. Meanwhile, the content of his presentation focused on programming as a research tool for students, or means for exploring questions and musings. He spoke of several projects he and his classes had carried out, including the development and refining of a "wordmaker" program: a linguistic model with power to invent pronounceable English "words".

Commentators for the computing panel were two computer specialists: Beth Lowd of the Lexington (Mass.) public schools, and Jane Manzelli of the Watertown (Mass.) public schools. Both delved into what proved to be the thorny issue of teacher training. Lowd acknowledged the risks that teachers take when they try seriously and imaginatively to make the computer a teaching tool in their classrooms: the threat to routine, the challenge to curricular regularity, the vulnerability in laying open one's assumptions about learning and teaching. On the one hand, she asked how we can help teachers to dare and endure such dangers, but, on the other hand, she warned against pushing too far, too fast. Manzelli reiterated this warning. There are "wonderful ideas", she said, which can simply never be carried out withinn the practical constraints of teaching in public schools. Both commentators contributed significantly to the emergence of a concern with the practical dimensions of school life, which remained for the duration of the conference an important counterpoint to a prevailing confidence in the innovative power of computer technology. Their commentary also sparked the conference's liveliest post-panel discussion.

<u>Language Arts</u>

The first panelist was Fay Wheeler, an educational computing consultant and recent collaborator in the pilot testing of an experimental thinking and writing skills curriculum. This curriculum, called <u>Waters' STEPS in Thinking and Writing,</u> views the writing process as a kind of problem solving, where success depends on applying the same cognitive and affective strategies that generally prove useful in attacking more concrete problems: strategies like looking at the problem from different angles, organizing available information, devising a plan, building stamina, etc. Its method is to encourage students to reflect on their thinking and working habits, and to hone these through guided practice in a range of problem-solving exercises that include interdisciplinary writing. The curriculum was designed for paper and pen, not the computer, but its concepts seem to invite the integration of a data base management program, so Wheeler and her teacher collaborator worked out the change. Then they ran an experiment: they taught one group of eighth graders the original STEPS, and a second the modified, computer-based version. The substance of Wheeler's panel presentation was her report of their findings. [For additional information on the STEPS curriculum, write F. Waters, 1153 Grove St., Framingham, Ma. 01701.]

The second panelist was Cindy Stevens, curriculum specialist in the Concord (Mass.) Public Schools, who described her system's experience with Quill , a computer-based writing program for elementary classrooms [DCH Educational Software, Lexington, Ma., 1985]. Quill's features correspond to phases in the writing process as described in recent research on the teaching of writing [See, for example, Graves, 1983]. Thus, in addition to a text editor, the software includes a "Planner" to structure and facilitate pre-writing experiences; a "Mailbag" to encourage and facilitate sharing and thus provide students what is called an "audience" for their writing; and a "Library" or electronic folder system which preserves the record of each writer's growth, and also gives the classroom community of writers access to each other's work by means of descriptors supplied by the authors or their teacher. This range of options makes Quill a classroom communication system rather than simply a support in language arts activities. So, for example, Stephens recounted how students in one Quill classroom had used the "Mailbag" to share their LOGO procedures with each other, and the "Library" to store them; and she also recounted how teachers had used the "Planner" to help in social studies and science teaching. In describing generally how the Concord teachers used the "Planner" option, Stephens cited several conventional pre-writing activities: a list of questions to consider before writing a restaurant review, for example. But she also cited two other examples quite unlike that which might have been handled just as well in paper worksheets. In the first of these , students created a planner themselves, that is, they used this feature of the software as a means of deliberately facing the inquiry and logical shaping that constitute the early stages of successful writing; and, in the second example, a teacher created a planner with students, that is, used the feature as a kind of electronic bulletin board for recording the product of a group effort to inquire and shape.

The commentator on these presentations was Henry Olds, an educational computing consultant. His commentary emphasized his view that the value of the computer in teaching writing is dependent ultimately on whether its use is faithful to the process of writing as a process of thinking, reflecting on thinking, and rethinking. He also used his commentary to move beyond the subject of this panel to address the training issue: how can we best help teachers to use applications software creatively in their teaching? Finally, in a visionary mood, he spoke of a new cognition that he thinks the computer may enable. Though he professed difficulty in finding language to describe it, he suggested tentatively that it has something to do with an ability to hold multiple hypotheses and their implications simultaneously "in mind", and thus to get a better bearing on the complex systems of reality.

CONFERENCE THEMES

What follows is an analysis of ideas which first surfaced during a panel presentation or discussion and then lingered in the conference air as a result of subsequent references. The analysis of these themes is based on an examination of the complete conference transcript, and has been reviewed and approved by a representative post-conference gathering of panelists and other conferees. The themes are here grouped under four headings: the computer and the curriculum; the computer and reality; perspectives on teaching practice; and teacher's professional development.

The Computer and the Curriculum

The first set of themes deals with the real and potential impact of the computer on the curricular status quo. According to the ETC Research Agenda (March 1984), "The computer is a Rorschach ink blot test for educational philosophy. . . so versatile, so rich in possibilities that virtually any view of what education is or ought to be can be implemented on it." As Allan November put it in the post-conference discussion, "Whoever comes to the computer, uses it like a mirror." But also like a mirror, suggested Stone Wiske, the computer lends an opportunity to question and adjust. Although educators may tend to view the potential of the computer in the curriculum one way or another depending on whether they are relatively pleased with the current curriculum or intent on remaking it, some may nevertheless find in this machine a catalyst for a significant shift in their thinking about curricular design and thrust.

Their comments suggest that a majority of the presenters, commentators, and participants at this conference are among those who would have the computer effect a major curricular transformation in the schools. Thus five of the following six themes derive from this perspective. The sixth derives from a perspective which is doubtlessly more prominent among educators generally than it was at this conference, a perspective which regards the computer more as curriculum supporter than transformer.

1. The computer keeps learning connected to experience.

This is the classic ideal of that end of the philosophical continuum that the ETC Research Agenda labels "Open Education". The common curriculum, in this view, often strips experience of its context, abstracts it to the point of inertness, and deprives students of an awareness of the connectedness of knowledge. Some see the computer preeminently as a means of avoiding this. Jon Choate, for example, described how the software "tools" he used in his mathematics teaching let him link that teaching to larger life experiences: "These kids really wanted to talk about drinking, and I had probably the best discussion I've ever had with a class talking about the problems of alcoholism using causal loop diagrams and system dynamics." It is the responsiveness of such tools as spreadsheets -- their capacity for quick analysis and display -- that makes them good tools for the teacher who wants to embed learning in experience. And they are tools that students can use also -- to do, in effect, the reverse of what the teacher does -- to extract meaning from experience. "I think," said Choate, "that the kids need these tools to examine what's around them." It is exactly this extraction of meaning from experience that Richard Houde meant when he observed delightedly that with the Geometric Supposer, "Geometry comes up when it's not supposed to."

Paul Goldenburg and Allan November of the computing panel also took up this theme, both describing the effort they make to keep their students' attention off the machines themselves and on the work the machines support. Goldenburg said he likes to show students how very simple, even "utterly trivial" programming can facilitate dealing with "not trivial" ideas. "The more kids have to talk to the machine," he warned, "the less attention they have to the intellectual content at hand." Teaching computing, he suggested, should mean empowering students for real experience in the world. November put it similarly: "The goal of my course is to make computers as invisible as they can possibly be."

2. The computer provides access to the underlying disciplines of subjects.

This was one goal of some curriculum innovation in the 1960's and early 70's, but the effort to reach it then relied largely on the content and direction of specially prepared materials. According to Susan Freel, the computer may be more powerful than these materials in creating the kind of learning environment necessary to authentic engagement with the disciplines. "We're not imparting knowledge anymore," she said of the teacher's role in such an environment. "We're facilitating." And so the students "create rather than receive knowledge. . . . They pilot rather than passenger their own learning."

Judah Schwartz indicated specifically how disciplinary engagement can occur in his analysis of the computer's role in applications like John Samp's thermistor experiment: "It allows you to focus your attention on the phenomenon. . . . What it does is that it provokes a kind of direct confrontation with some of the subtleties of what's going on," and this in turn, he added, may provoke the student to ask why. In this sense, the computer becomes a key tool in what Pat Davidson called "the art of problem posing". And problem posing is the heart of disciplined inquiry, as Richard Houde suggested when he described his students as "creating geometry" in a kind of geometrician's seminar based on mutual problem posing.

3. The computer has an inherent power to challenge the curricular status quo. That is, the computer, by its very nature, threatens the curriculum's preoccupation with sequence and linearity; its focus on the delivery of information; its tendency to substitute a petty accounting of the details of knowledge for attention to the process of knowing; and its nearly exclusive reliance on classroom-based, teacher-centered instruction.

The remarks that made this most prominently a conference theme were those that attended to the potential of the computer to put play into learning in school. Here the word play sometimes meant a mode of exploration, experimentation, and risk-taking regarded as integral to intellectual facility. So Hal Abelson celebrated the fact that microworlds like Dynaturtle bestow on children "the freedom to muck around". And, observed Judah Schwartz, "the absolutely delicious thing" about this mucking around "is that there is no end of big ideas that you keep stumbling across."

Just as often, however, the word play had a more restrictive meaning though no less benign an association for its user. So Richard Houde, responding to the misgivings of a conferee who had noticed some distortion in the Supposer's graphics, said this: "I want the kids to play with mathematics and I don't want exactness to get in the way of the play. I'm willing to overlook some of the inexactness." And Jon Choate, speaking of spreadsheets, said, "What's so neat about this is they can play with the data. It's nice to have a tool where you can say, What happens if the data is really crunched together? What does that tell me? What happens if the data is spread out?"

But whether the computer-induced play was seen as microworldly or specific to some disciplinary context, it was nevertheless viewed as implicitly contradictory to the common mode of learning and teaching in school. And that spelled trouble for the computer's prospects in school, as far as some conferees were concerned. One remarked: "I see us all as a small minority within our own school systems, and I see, when we go back, a larger group of people who are going to be very resistant [to] this. . . .I'm going to hear people say, 'I don't have time to [illegible] [c]ive.' If we take these great programs and let the kids [illegible] [t]wo days, four days, a week, six weeks 'playing', these [illegible] are going to say, 'I'll never get through chapter 19.'"

[T]wo presenters, John Samp, and Bill Read, acknowledged this conflict as not only a question of preferred pedagogical technique, but also, and preeminently, a question of time. To play with the computer takes time, and this loss of time, in their view, is inevitably a loss of curricular "coverage" as well.

Nor is only coverage at risk, but perhaps sequence as well. What happens, asked one conferee, when "you're working with a problem on p.27, and the student [playing with Supposer] comes up with an idea that's on p. 97?"

Beth Lowd contemplated the effects on teachers of the "radical surgery on the schools" she thought implicit in the advent of educational computing. "The emphasis on process is scary because you don't know the content a kid is going to come up with. It means there's no right answer." Similarly, Allan November foresaw great change, but forecast that it would ripen slowly. He drew an analogy between the introduction of computers into school and the introduction of fiberglass into boat building. The first fiberglass boats, he told the conference, maintained the lines and sometimes even the texture of wooden boats. Only much later did boat builders let the unique qualities of the new material define new shapes. "We're so stuck in our sort of structural design of the classroom," he explained, "that we're not going to see the integrity of this machine [the computer]. . . . The integrity of this machine means that the relationship between teachers, the design of the physical plant, whether kids are working with old people or young people, or in a physics course or a math course -- those things are not relevant anymore."

4. The computer aids implementation of the curriculum.

Bill Read's Dynaturtle case study was essentially the story of how he lashed what he saw as latent teaching potential in the software to a topic in his system's second grade science curriculum. At one point he deliberately distanced himself from the "open" or microworld approach to Dynaturtle: "According to Andy DiSessa who designed this, people have approached this in many ways. Some people have worked with it trial and error for hours at a time to try to figure it out. [However] faced with a very tight schedule, and worried that the children wouldn't relate to this, I was in the business of at some point giving them some clues as to what to do." Near the end of his presentation, he called upon software designers to create simulations that correspond to topics at various levels of the elementary science curriculum; he envisioned, for example, children exploring the concept of the pulley through a simulated ride on a ten-speed bike. "What I'm thinking about," he explained, "is the children would have access to computer programs which teach a real task and in the process of doing the real task, there is some princ[illegible] involved which the children may or may not be able to exte[illegible]." This link to a particular principle is explicitly purposive, teacher-directed, and so quite different from the link Hal Abelson had in mind when he said in his commentary: " Dynaturtle links to deep things. . . . We tend to call these things in logo 'microworlds'. One of the characteristics of a microworld is that somehow it doesn't have boundaries. Something that has to enter our vocabulary better when we think about these things is the difference between a simulation and this other sort of thing, somehow a difference between discovering and having the freedom to muck around." This subtle but important distinction establishes the line between those computer advocates, like Abelson, who would upset the curricular status quo, and those, like Read, who would enrich it.

John Samp's work was similar to Read's in its curricular grounding; he had used the thermistor not to change the physics curriculum, but to teach it more effectively. At one point in the post-panel discussion, a conferee, presumably reacting negatively to Samp's focus on the curriculum, asked him if he considered it important to teach students how to regard computers as "toolmakers"; Samp responded coolly and rhetorically, "Am I going to do this at the expense of some of the other concepts I'd really like to cover in a physics course?"

Cindy Stevens might have described Quill as a microworld with power to transform the teaching of writing and even the place of writing in the elementary classroom. Indeed it was thus described at the next ETC Conference [See ETC Conference Report, Microworlds and Expert Systems, 1985]. She tended instead to emphasize its usefulness in reaching already established teaching goals. So, for example, she claimed that children are more likely to recognize their errors of spelling, capitalization, and punctuation in text they have processed and printed than in text they have handwritten. She also spoke of Quill's "mailbag" feature not as a stimulus to letter writing among children, but as a means for teachers to respond more easily to writing children address to them.

The Computer and Reality

A concern with the object of learning, which marked the first grouping of themes, is here replaced by a concern with the quality of learning. Each of the three themes in this section takes a different cut at the question of how knowing and experiencing via computer are like and unlike knowing and experiencing in more direct and concrete ways. The three cuts are, in turn, epistemological, psychological, and pedagogic.

1. Computer-based models and simulations only imperfectly represent reality.

Hal Abelson said, "It's very tricky to say what kids actually get from playing around in these [micro]worlds. You have to beware of the audiovisual simulation trap." Just as there is no exact correspondence between computer image and its referent in concrete experience, he suggested, so there is no simple correspondence between what is learned in working with one and what might be learned by working with the other.

Judah Schwartz issued the warning more strongly: "There is a temptation to use computers to replace nature." While he granted the value in taking "one system that represents some other system, and you use each to gain insights about the other," he suggested that the trick to such teaching lies in maintaining distinctions between the systems. So, for example, one might reasonably compare the dynamics of the Dynaturtle chevron to those of space flight, but one must acknowledge as well the "dissonance" in the comparison: with Dynaturtle "you need a force to change the linear motion, but you don't need a torque to change the rotational motion." Even better than acknowledging such dissonance, he added, is provoking students to discover it themselves.

Susan Freel offered still another trick to avoiding the simulation "trap" in teaching. Commenting on Jon Choate's presentation of mathematical modeling, she urged teachers to "bridge that gap for students" between models and the reality they imperfectly represent by teaching them how models work. She suggested, for example, that one might take a common model like Lemonade, "and not use it for the content it's presenting, but use it for investigating the model that's there."

The issue of the imperfectability of simulated experience arose again in the discussion period following the language arts panel, when one conferee described word processing as a kind of simulated writing in which the complicated writing flow has been reconstituted in order to make its components individually manipulable. But there is a price for this convenience, he added. The writer must be content with "screenfuls" of text instead of "having the whole thing" at once.

Henry Olds counterbalanced some of the conference concern with the computer's metaphysical limitations by suggesting that, despite them, the computer has the power to portray reality in greater complexity than any other analytical medium. It enhances cognition, he said, by enabling multiple hypothesis "holding", intensive questioning, and better perception of interconnectedness. "The computer may have come along just at the right time to save us," he added.

2. A program may mask operations that students should directly experience to give depth and stability to their learning.

Here the "reality" is not some concrete referent, but rather an intrinsic part of what the computer does when it "assists" the student in accomplishing some t k.

The two references to this issue in the course of the conference illustrated two different and somewhat contrary aspects of it. First was Allan November's comment: "I've got a lot of kids who don't know whether you multiply or divide to get averages, and spreadsheets let you just do an average for these numbers, and the kids get it, but they don't have the conceptual sense of what they're doing. . . . I'm concerned about spreadsheets being too seductive."

Considering this masking function of spreadsheets from a different angle, Fay Wheeler found that what is lost in the masking may be less significant than what is gained -- namely time to work on higher order skills. In her STEPS experiment, Wheeler found that the control group of students, managing an elaborate research project without benefit of computer, could not do all three of the project phases the computer-using group managed easily: collecting data, analyzing data, and reporting results. Such time-squeezes, she added, typically result in shortchanging the last and higher order phase.

3. Computers sometimes need to be used in conjunction with manipulable objects, or in association with other, more concrete experience.

In her commentary on Richard Houde's presentation, Pat Davidson referred to the VanHiele "levels of learning geometry" [See VanHiele and VanHiele-Geldos, 1958; or for a succinct and readable presentation, see Hoffer, 1981.]. Davidson emphasized that the VanHiele levels are not developmental, but rather experiential levels; that is, one advances from one to another as a result of exposure and practice, not maturation. The levels are, nevertheless, levels of abstraction. According to Davidson's analysis, one value of the Geometric Supposer is its capacity for shifting students' geometric experience among the three middle levels in VanHiele's hierarchy; on the other hand, the Supposer offers no exposure to the first and most concrete of the levels, nor to the final and most abstract. Houde had already acknowledged the latter fact in citing the need to go beyond the Supposer in teaching proofs, for example; but Davidson's observation of the software's inadequacy on the concrete level, seemed to strike him as fresh and valuable information. In the post-panel discussion, he made a point of mentioning that he would henceforth follow her suggestion to use miras as concrete companions to the Supposer in his geometry teaching [Davidson's definition of mira: "A device that allows you. . . to construct perpindicular bisects and angle bisects through the use of reflection." Available from Creative Publications, 5005 W. 110th St., Oak Lawn, Ill. 60453.]

When Bill Read first met Dynaturtle , he associated its dynamics with the dynamics of space flight. He found the association felicitous because the physics of space flight fit well with the science curriculum of the second grade, and also because a second grade teacher had recently asked him to teach her students a lesson that capitalized on their interest in Sally Ride's space flight. It is conceivable, of course, that it was largely these circumstances that prompted the association. In any case, Reed felt that in order for the students to see the association he saw, they would need some concrete, intermediate experience. As he put it in his presentation, "I began to worry whether the abstraction of Dynaturtle would be just too much for the total situation, so I tried to figure how to connect it up with solid, 3-D things. . . . One of the things I did was to have them look at my models of space ships of various American flights." He also had them build their own models of space ships, and view a film about the first landing on the moon.

Some conferees found the "connection" he sought here a problematic one. Paul Goldenburg, for example, questioned the possibility of a "transfer" effect between Dynaturtle and Read's concrete analogs. Young children, he said, are good at compartmentalizing experiences, and so might say of Dynaturtle, "Well, that's the way THAT works," without assuming any relevance to the construction of model space ships or the dynamics of real ones. Hal Abelson questioned what he regarded as Read's implicit assumption of where "reality" lies: "It has to be a strange kid for whom the thought of piloting a space ship somewhere is more 'real' than the thought of playing with this thing on the computer."

Perspectives on Teaching Practice

The unusual format of this conference, spotlighting teachers' presentations of their work, offered valuable and rare glimpses of the dynamics of teaching. The value of the format may reside as much in these glimpses and how they may inform research and policy, as in the applicability of these teachers' experiences to other teachers' situations.

1. Teaching is rooted in a teacher's own interests, need to understand, and sense of social commitment.

Among others, John Dewey insisted on this view of teaching [See Dewey, 1916; Fenstermacher, 1979; Buchmann, 1984.] The views of teaching common in the university and among school administrators do not necessarily conflict with this notion of the work's personal roots, but they typically overlook it or underemphasize its importance. Thus the university seems often to view teaching as if it can be properly grounded only in the psychological and sociological knowledge that the university creates. And school administrators appear to wish it grounded exclusively in curriculum theory, which is essentially the same knowledge one step removed from the university by virtue of some process that integrates it both with subject matter and with the common structural features of classroom practice. [For an expression of what is called here the university view, see "Is Graduate Education Fulfilling Its Responsibilities to Primary and Secondary Education? 1982; for an expression of what is called here the administrator's view, see W.H. Schubert, et al., 1983. In the latter document, one curriculum leader is quoted as follows: "...If a teacher can't explain exactly why he/she is doing any given activity with any given child (at any point in time), then there is need for more study of theory."]

The classic assumption of how teaching reform must proceed runs something like this: identify a need, find an effective teaching strategy, sell it to the teachers. But in describing the course of his Supposer experiment, Richard Houde reversed this assumption: "I thought, first, it was very interesting; second, I saw a few kids use it and they seemed to really enjoy it; and, third, I said to myself, how can I make my teaching better?"

Allan November accounted for the fact that his computer literacy course produced a service directory for handicapped people in terms of his view of teaching as social action. "I'm not interested in computers," he declared. "I'm interested in how kids fit into their community." Jon Choate cited what he called his teaching "biases": that the world is a "special" place and math helps one see its beauty; that the world is in trouble and we all must do something about it; and that math applications can be one of the tools we employ in this effort.

Bill Read vividly described the effort he must make at the start of a teaching plan to root it in his own interest and experience: "One of the problems in talking about programs for second graders is to try to get yourself psyched up to take it seriously. . . . It's a difficult psychological problem, and in order to get myself into it, I have to. . . make up a scenario, get myself all worked up emotionally. . . and then when I get myself psyched up to that point, then maybe the ideas start to come about what to try." Read suggested furthermore, in a throwaway line, that this grounding in the teacher's psychology provides the conceptual map by which teaching proceeds. " In my mind "[my emphasis], he said, I had to attempt to make the connection between Dynaturtle and something which was real enough to carry around in their minds."

2. Teaching is, to a significant extent, a product of circumstance, not an entirely rational enterprise.

Some scholars of teaching practice have suggested that much research on teaching may be seriously flawed by virtue of its conception of the enterprise as essentially reducible to objectives and strategies to achieve them [See, for example, Eisner, 1983; also Tom, 1984; also Buchmann, 1984]. In this maverick view, such reductiveness, though perhaps usefu'l in planning and in retrospective evaluation, fails to account for the large part of teaching that involves intuition, spontaneity, conflict and negotiation, and simple circumstance.

At the beginning of her presentation, Fay Wheeler said, "There are three reasons why we decided to use a data-base program in this curriculum [Waters' STEPS]." But there she paused momentarily, then added, "Actually that's not really true. Initially we just said, 'It sounds like it would fit so let's <u>do</u> it', and in thinking back, I guess, I came up with three reasons."

Bill Read accounted for his <u>Dynaturtle</u> -space lesson as arising from circumstance: Sally Ride's ride and the interest some second graders took in it; their teacher's wish for a science teaching demonstration; and the fact that his system's computer coordinator had just recently shown Read the software.

Jon Choate also credited certain circumstances for giving rise to a teaching experience he described and clearly remembered fondly. The circumstances were, first, that his school was living through a difficult case involving drug and alcohol abuse; second, that he happened to be head of the school's Discipline Committee; and, third, that he had software on hand in his classroom that he intended to use in teaching problem analysis. These all came together one day as he faced a class. Here is how he recounted it: "These kids really wanted to talk about drinking. And I had probably the best discussion I've ever had with a class talking about the problems of alcoholism, using causal loop diagrams and system dynamics. We never built a model; we never needed to. But we were able to diagram all the dynamics in the problem. We were able to talk about all the problems in alcoholism and really put it in some sort of meaningful context. That's pretty powerful right there." If this image of teaching as at least partially circumstance-driven has validity, then the responsiveness of the computer -- <u>to the teacher and in the classroom</u> -- becomes a key element of its potential to improve teaching and learning in schools. This in turn has major implications for the design of software and for the design and allocation of hardware. Note Choate's final remark on the incident: "To be in a math classroom [and] to have a tool where you can do that is, I think, important."

Allan November described a simpler, more mundane teaching experience that in some respects was just like Choate's. He was trying to get one girl to break through what he called her resistance to using a graphing program, and as he stood there urging her to think of some variable to graph, the perfect solution occurred to both of them. She would graph her classmates' earring collections. It was the spontaneity of its discovery, November suggested, that let this student "own" this earring problem. Owning the problem is "critical", he said.

3. Teaching and learning are only loosely coupled. Teaching does not so much cause effects as create conditions that in turn cause effects, and a good part of a teacher's work involves riding herd on these second-hand effects.

Why one may not be able to draw unbroken arrows between teaching objectives and learning effects is an open question. Some suggest, obviously enough, that the main reason is that a human learner, with personal purposes, moods, and consciousness, sits at the receiving end of these putative arrows. Some add that this receiver-of-the-action almost always exists in the plural, that group dynamics therefore deflect the arrows; and that the structure of the subject under study also has a mediating influence. [Tom; Eisner; Lazerson, et al., 1985, p. 109; also Shulman, 1974.]

Bill Read suggested that teaching is like channeling a fast, fluid stream of largely unpredictable events. Here is how he described one moment of it: "I was kind of structuring as I went along because I would say you really have to do it a certain way, and I did it a certain way. In other words, I was right with them, jumping around much of the time." His "jumping around" is quite purposeful; but it is less an effort to create effects than it is an effort to keep up with them, to recognize them as they fly by. Here is Read again, nearly breathless: "I tried to find out were they making sense of this, did they have the jets in the right place and did the jets make the thing move correctly, and so forth and so forth. I kind of moved back and forth. One of the realities of trying to have second graders on machines which they'd never seen before and I'd never seen before, and we had a very short time to use them -- we rush in, we sit down. Here's how you do it, you do it. If they need me, I have to jump around." The fast fluidity in teaching work that Read captures in his comment contrasts sharply with an image of teaching and learning as linked in a simple cause and effect relationship, and suggests instead a far less deterministic relationship between them. And so Read confirms in discussing his project's results: "I'm not sure exactly how many of the kids made the connections. . . . Maybe 25% would get it one day and maybe some more on another day, and some people at the end of a month still didn't have an understanding."

One important implication here is that the teacher must learn to cope at best with a great deal of uncertainty as to the effects of his or her work, and at worst, with a very high failure rate. Even good teachers who stay both demanding and hopeful -- and the presenters at this conference are clearly of this variety -- must do so on the slimmest faith. Allan November acknowledged that when he looks coldly at his work's effect, he must acknowledge, "I'm only getting less than half of my kids looking around this room and knowing how to. . . do a data base on people in this room at this moment. The other half of my kids won't see it when they go into a new environment." Paul Goldenburg was even stronger on this point: "We have the luxury of two and a half teachers. . . in a classroom of a maximum of 15 students, and we fail miserably. . . . I mean, we have successes too -- I told you about one. But by and large, the feeling that I get most of the time when I go home is I'm not accomplishing anything."

Teachers' Professional Development

By and large, this conference was a gathering of teachers and others who had already begun to work out a place for the computer in their work -- members of what several conferees called the first wave of computing educators. Although an important function of the conference was to give these first wavers an opportunity to consider and share what they had learned, an equally important one of its functions was to help them think about how to encourage a second wave among their colleagues. Many of the comments on this issue offered an answer to either of two strategy questions: What should we do, and what should we avoid in the training of second wave teachers? And several comments addressed a deeper question too: What, after all, is the goal of training?

1. Strategies.

During one post-panel discussion, a conferee announced "Today, I'm learning how much I don't know." It was not an anxious remark, but was, on the contrary, somewhat celebratory. After all, this is the classic way to begin an education.

But having learned the scope of his or her ignorance, what does a teacher do next? In answering this question, Susan Freel suggested that what is needed first is a way to see the ends of one's efforts, and so she called for the development of "some kind of expectation manual for teachers. . . . We all need a little bit of sense in these new open environments which we're taking more risk-taking in, about what we might expect from the students we're working with." Henry Olds, by contrast, focused on means rather than ends: "We need examples, really good, well thought-out examples of how these things can be used in the classroom. . . . Companies now design templates for using tools. . . . There's a need for this in education. . . . a whole new genre of materials."

Beth Lowd cautioned, "I think it's very easy for us who are in the first wave to try to go too fast. . . . We have to go slowly with this larger group of teachers. . . . They have a hard time accepting the degree of change we're asking them to accept."

She detailed a training plan to move this group's teaching to what she regards as the implicit goal of computing in the curriculum. The first stage of her plan is to "get them to use CAI. . . simple drill and practice. . . helping them to explore things on a very, very simple, not very different from what they're doing kind of level. Then. . . you can begin to move them from just changing the medium to changing the mode of their teaching, for example, using a simulation, a game." Then in the final stage comes "changing the message", that is teaching teachers "to concentrate on process rather than content." Lowd described these stages as if they were quasi-developmental, and thus especially important for trainers to respect. She said of her own training work, "I'm trying very hard to discipline myself to help people take these steps. It's very difficult [though] because I want to leap them onwards."

Allan November described his approach to training: "The one thing I teach better than anything else is. . . how to fail and pick yourself up. I learned this as an Outward Bound instructor. . . . The whole idea of Outward Bound is that you get up there on that log or on that cliff, and you have to depend on other people; there's just no choice about it. When I do workshops with teachers, I take an Outward Bound approach with them. . . the sense of teamwork, the sense of asking for help, the sense of sharing, of saying 'I don't know', the sense of looking over each other's shoulder."

2. Goals.

This was a conference where many seemed to regard the computer as a potential and very welcome transformer of teaching and learning in schools. There was at times ebullient optimism in the conference room about how this potential might become actual. some seemed convinced that the technology itself might have some power to effect change. So, for example, Henry Olds said that software like Quill -- designed to fit the writing process -- might through sheer contact give some teachers insight into writing and inspiration thereby to reorient their teaching. But others were less sanguine. There was, warned Beth Lowd, the obstacle of the many "dead" teachers who will never accomodate themselves to the computer's liveliness. Although many conferees took issue with this remark, and Lowd herself later toned it down, it nevertheless had an effect in tempering conference optimism with an image of schools' obstinacy. Thus Pat Davidson's earlier question -- "How do you train teachers to be good problem posers and to be flexible?" -- seemed by the conference's end a more complex, and more difficult question than it had seemed when she uttered it. In a post-conference discussion, even Allan November and Richard Houde seemed less optimistic, with Houde citing the great power of the curricular status quo, and November citing his suspicion that many people who go into teaching like things "linear and unchanged". Still Jane Manzelli's remark late in the conference probably came closest to the final conference mcod. "When I see six wonderful teachers give a presentation, I know they have gone through some process where they got beyond who they were." She urged the conferees to think carefully about what that process might be.

CONCLUSION

To understand a complex affair like this conference, it is useful to identify and lay out its themes side by side. Nevertheless, such an analytic technique may also inadvertently suggest that the issues these themes address can similarly be cleanly distinguished from each other. In fact, however, computer training for teachers and all the questions or concerns we may have about it must be viewed in terms of what we know about the computer itself and its relation to knowledge and experience, about what we want its effects on the curriculum to be, and on what we know about the nature of teaching practice. These areas are separate only as areas of inquiry, but they remain indissolubly linked in school life. And they maintained this intimate and complex association with each other in this conference as well. That is why, if one is really to understand the conference, one must try imaginatively to take the themes, now laid end to end in the long list above, and lay them on top of each other like overleaf transparencies.

The following questions, though far from an exhaustive list, are meant to facilitate this search for the correspondences among theme groupings, those places where images on the separate transparencies seem to match up. They also constitute a call for research, development, and reflective practice. As such, they seem an appropriate ending for a report about this conference, given the mission of the conference.

Is the computer, when used to its full educative potential, inherently antagonistic to the curricular status quo?

If so, what is the precise nature of its challenge, and what are the implications of this challenge for teaching practice, teacher training, classroom and school organization, hardware and software design?

If the challenge is massive, how can it overcome the conservatism of schools? What motivation exists for accomodating it? What kind of professional development, organizational development, or other implementation mechanisms can serve such an end?

If, on the other hand, the effects of the computer on the curriculum are likely to be more modest, then what will be their scope, and does this scope justify whatever expense and disruption are entailed?

What are the proper roles of the computer vis a vis direct experience, and what do they imply for curricular design, teacher practice and teacher training, hardware and software design?

To what extent must using the computer be an essentially solitary learning experience, and to what extent can it happen in groups? Again, what are the implications of these measures for teacher practice and training, hardware and software design, and also for curriculum development, and computer allocation within buildings?

What are the implications for educational hardware and software design of such notions about teaching practice as that it is rooted in the psychology of the teacher rather than simply in that of the student, or that it is not entirely reducible to rational dimensions?

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