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ABSTRACT

This paper first reviews the field of educational technology and teaching from two perspectives, that of the technologist and that of the teacher. It is noted that the activities of educational technologists are now defined largely in terms of instructional design and development and are increasingly distanced from the work of ordinary teachers in the public schools; and that the teacher's world is substantially limited by powerful social and administrative pressures to teach in particular ways, which results in very little opportunity to deal with educational technology as something larger than machines and software. The paper then characterizes the current state of the movement to radically restructure education, and suggests how educational technologists might join in and contribute to that discussion, the central issues of which focus upon democratizing school administration; teacher self-management and professional development; altered classroom roles and emphasis on critical thinking skills; and new modes of research on teaching and teacher preparation. The paper concludes with suggestions, drawn from current research on teaching and educational practice, for new initiatives that educational technologists might take in four areas: (1) the preparation of models for teaching-with-technology; (2) the design of intelligent software; (3) the creation of technologically-based tools to support teachers' professional work and development; and (4) the improvement of research on technology in education. (78 references) (CGD)

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Teachers and Technology: An Appropriate Model to Link Research with Practice

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Teachers and Technology:

An Appropriate Model to Link Research with Practice

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Teachers and Technology:

An Appropriate Model to Link Research with Practice

This paper grows out of an increasing frustration with the direction taken by research, development, and practice in the field of educational technology over the past dozen years. That frustration has roots that are complex, but the tension itself may be simply expressed: although educational technology was in its origins intimately connected with the work of teachers and schools, in recent years the focus of the field has increasingly shifted toward applications in business, industry, and higher education. Those research studies, development and implementation projects, and evaluation reports that do concern themselves with K-12 settings may take a diffusion-and-adoption approach to teachers' use of hardware, consider a particular medium's effectiveness as an instructional tool to reach particular objectives, or examine the applicability of some specific instructional development (ID) model to the organization and delivery of curricular material in one or more subject domains.

Those educational technologists who have surveyed the scene in the public schools (e.g., Heinich, 1984, 1985) often assert that the only sensible approach is to encourage rapid and comprehensive acceptance of a strict ID approach to the design, implementation, and evaluation of instruction in the schools. Heinich particularly decries the continued "craft" approach to their work among teachers, and sets this in opposition to a "technological" approach. The field of educational technology, he suggests, has more to do with technology than it does with education. Others (e.g., Branson, 1987) are less specific in their criticism, but intimate that the rationale for the existence of schools (almost always discussed in terms of knowledge production and transfer of information to

the next generation) has been so seriously impacted by technology and other changes that their presence as a social institution past the year 2000 must be questioned.

This is what I find troubling, for schools as a social institution collectively have other (and, many would argue, more important) purposes than the transmission of information to their charges. Teachers, too, are more than classroom-based implementors of instructional strategies. In fact, there has been during the past years much discussion about the radical reform of schooling, and about teachers' key role in that process, discussion which educational technologists (with a very few notable exceptions) do not seem to have acknowledged, much less joined. If schools and teachers will continue to exist in some form, then, and if the largely antithetical positions described here are in fact representative of teachers' and technologists' views, how should educational technologists concerned with public education proceed?

This paper first reviews educational technology and teaching, considering each field from two perspectives--that of the technologist, and that of the teacher. It then characterizes the current state of the movement to radically restructure education, and suggests how educational technologists might join in and contribute to that discussion. It concludes with suggestions, drawn from current research on teaching and on educational practice, for new initiatives that educational technologists might take in four areas: (1) the preparation of models for teaching-with-technology; (2) the design of intelligent software; (3) the creation of technologically-based tools to support teachers' professional work and development; and (4) the improvement of research about technology in education.

Educational Technology

The technologist's vision. I do not need to recite here the recent history of the field of educational technology. Others have adequately chronicled the gradual transition from a focus on devices to a concern with process, the shift to an emphasis on the definition of systematic instructional models and procedures, and the gradual growth of interest in cognitive as well as behavioral principles as conceptual underpinning for the field (Reiser, 1987; Saettler, 1968).

The result of this activity has been the creation of instructional design and development, a combination of elegant instructional models (design) and practical procedures (development) for the delivery of instruction. No one can really deny at this point the popularity and practical appeal of ID as an approach--note the rapid growth of DID within AECT, the concomitant growth of other similar associations and groups (NSPI, ASTD, etc.), and the success of ID as an approach in business and industry (evidenced by the expenditure by businesses of an amount annually roughly equivalent to all the costs of higher education in this country).

The point is that activities of educational technologists, defined now largely in terms of instructional design and development, are increasingly distanced from the work of ordinary teachers in the public schools. Richey (1986), for example, opens her book with the following:

> Planning instructional programs and materials has been separated from the jobs of those who actually deliver the instruction in a growing number of situations.... The dichotomy between instruction and instructional design ... is ... influenced by different theoretical orientations and different practice histories (p. 2).

The fact of this division is, however, something about which I feel that we as a field must be concerned.

Schools, then, have been notably and curiously removed from the concerns of technologists. Those who have looked at schools seem to feel that, if only teachers would use ID approaches, classroom practice would be vastly improved. Students would become motivated, instruction would become clear and logical, student achievement would increase, teachers would be freed from the drudgery of routine tasks, and classroom activities would become more varied (e.g., Reigeluth, 1987). The appearance recently of a special thematic issue of JID on "ID and the Public Schools" (Salisbury, 1987) testifies to the scarcity of this approach in general.

The vision has been remarkably consistent. The problem has been that teachers have been slow to respond, either to the blandishments of those who have encouraged teachers to use technology-as-hardware, or to the suggestions of those who have maintained that ID might provide solutions to educational problems. As Goodlad (1984) and Cuban (1984) have pointed out, most classroom practice today looks remarkably like classroom practice 80 or 100 years ago. The expectations and hopes of technologists have changed; reality, in the main, has not.

The teacher's vision. Yet classroom teachers do turn to educational technology, if often for reasons other than those technologists might hope. For most teachers, "educational technology" still implies hardware and associated software, not the process approach of ID. Showing films and tapes, for example, offers relief from the routine of classroom interaction, and many teachers choose consciously to do this. Cuban (1986) quotes a teacher, "Sometimes the motor needs to idle before it is put back into gear"

(p. 69). Films and tapes may also provide a "trigger," a stimulus in conjunction with work toward "expressive outcomes" of learning that are purposely not defined by the teacher in advance (Eisner, 1979). Programs and software used in such an exploratory fashion may also open an avenue for experiencing the world in ways otherwise impossible (Copeland, 1984, 1986).

Working with the tools of technology may also provide for students opportunities for personal empowerment and personal liberation not otherwise easily found in classrooms. Ellsworth (1987), for example, described the ways in which the production of videotapes could enhance students' awareness of social problems and their sense of empowerment to act in regard to those problems. And Schwartz (1987) used video with underprivileged youngsters to engage them in academic activities that otherwise would have been unlikely to succeed. Most teachers probably see such approaches as more essential to their roles as teachers and to the learning of their students than a strictly defined application of instructional design and development. When teachers do confront the technologist's vision of precisely engineered materials, controlled experiences, and measured outcomes, they may react not with enthusiasm but with rejection (Nunan, 1983).

Only a few researchers have consciously attempted to define teachers uses of and ideas about technology. Cuban's (1986) book is one notable exception; another is the work of David Cohen (1987) at Michigan. Both argue that the teacher's world is substantially limited by powerful social and administrative pressures to teach in particular ways. Even if teachers did want to think about educational technology as something larger than machines and software, they have remarkably little opportunity to do so. Teachers are not provided with or taught how to use more helpful alternative models during teacher training.

Teaching

The technologist's vision. The metaphors used in descriptions of educational technology tell us much about technologists' views of the instructors with whom they work. Hlynka and Nelson (1985) identified three dominant metaphors for educational technology in the literature of the field: "tools," "engineering," and "systemic" (in a broad artistic and aesthetic sense which they likened to musical performance). Unfortunately, many technologists unconsciously adopt either the "tools" or "engineering" metaphors. For these, teaching might be defined as the administration of instructional materials or programs in such a way as to effect learning. While lip service has been paid to the possibility of addressing all types of purposes of schooling--the affective as well as the cognitive, the long-term as well as the short, the "higher-order" and critical/synthetic/judgmental as well as the factual and objective--in fact most studies in the field focus on the latter part of each of these relations.

In fact, the way that many educational technologists think and write about teaching suggests that the teacher's role is something to be refined and shaped by principles of instructional design: inconsistencies are to be smoothed out, digressions eliminated, predictability developed. The principal product of the educational technologist's work--a carefully prepared set of instructional procedures--is designed in such a way as to minimize the teacher's contribution. Indeed, many educational technologists would posit that an important aspect of their work is to eliminate the need to have a human instructor present.

Educational technologists have also been seen as "change agents," encouragers of new instructional practices and procedures. Visions of

educational change are thus also important for us to examine in seeking to understand technologists' views of teaching. Earlier experience has cautioned those educational technologists most eager to redefine the teacher's role in terms of dependency on engineered design. Attempts in the 1950s and 1960s to penetrate the education market with teaching machines with names such as "techno-teacher" and "auto-tutor" proved notably unsuccessful, and the intensely designed (and thus "teacher-proof") curricula of the 1960s (PSSC Physics, MACOS, etc.) either failed to win acceptance, or were nominally accepted but modified in practice to such an extent that they became indistinguishable from the preceding classroom routine.

These problems led educational technologists to conclude that "teacher adoption" of new instructional strategies was a topic worthy of study. Early ideas about how to change schools were dominated by "rational-empirical" assumptions (Chin & Benne, 1969): showing people improved practices should lead them to change what they do. Typologies were constructed of "innovators," "early adopters," and so on (Rogers, 1962).

Most educational technologists have accepted the assumptions of the rational-empirical model. They also made other assumptions--that teachers find technology (qua hardware and software) easy to use, that technology (qua process) readily fits into the context of classroom activities, and that instruction should become a rational science. Studies based on this model of change examined teachers not only as users of educational technology but also as potential barriers to its use. Teachers' attitudes toward computers, their willingness to change, the extent of their acceptance of technology have all been considered. "Resistance to change" has been a central topic for discussion, and infusion of technology-as-

hardware and technology-as-process have been taken as a given for the improvement of teaching.

The teacher's vision. Defining what teachers think their work consists of turns out not to be an easy task. Several studies of classroom life have portrayed teachers as earnest, but harried. The job of managing 25 or 30 young people in a confined space for many hours each day explains why "classroom management" is such a perennial favorite in-service workshop topic among teachers. That teaching is work (and thus not always the glamorous "life of the mind" or pleasant "being with children" that some pre-service teachers hope), that it is hard (elementary schools experience a turnover of more than 7% of their teachers each year; secondary schools, more than 6%; Center, 1987), and that it provides few rewards other than the psychic are facts about their careers that most teachers recognize only after they have been teaching for a year or two.

Nevertheless, teachers do usually create for themselves a classroom world that reflects both their teaching style and their preferred ways of working with students. Characteristics of that world have been limned in several studies over the past several years (Lortie, 1975; Dreeben, 1973; Jackson, 1986): teachers often feel isolated from their peers, but find sustenance in the routine of classroom life; they resent intrusion from outside, and find most administrative requirements to be "red tape" that they would rather do without; their interest in constructing curriculum themselves or developing alternative instructional materials (other than a traditional textbook) is severely constrained by a lack of time for anything other than the most basic classroom maintenance, leading in turn to an almost overwhelming demand for "the practical" (Doyle & Ponder, 1977/78) in

approaches, materials, or hardware.

In addition to these general features of classroom life, recent studies on the professional knowledge base of teaching, teachers' thought processes, and the school setting have illustrated the demands on attention and effort that a teacher typically must cope with in daily work (e.g., Feiman-Nemser & Floden, 1986). Research on teacher thinking has pointed out the dilemmas and uncertainty that teachers routinely face (Clark, 1988; Peterson, 1988). Inquiry into the nature of teachers' professional knowledge has suggested that the links between teaching practices and particular curriculum content may be more subject-specific than previously thought (e.g., Shulman, 1987). And teachers have been urged to become more professional not by adopting a routinistic approach to problem solving, but by becoming more "reflective" (Schon, 1987) and by celebrating, not rejecting, the image of their work as a craft (Greene, 1984). In all these cases, emerging evidence highlights aspects of the teacher's work that are ambiguous, uncertain, difficult to cast into the molds educational technologists have wrought.

Educational Reform and the Educational Technologist

The past six years have witnessed a growing interest in general educational reform. Perceived declines in academic standards led to a number of critical reports in the early 1980s (e.g., National, 1983; Boyer, 1983; Education Commission, 1983). Student abilities in mathematics and science became objects of special concern (National Science Board, 1983; College Board, 1983). Among the other problems dealt with in this phase of the reform movement were: the role schools play in the national economy; the effectiveness of schools in providing students with a core set of cultural assumptions and values; and the need to accommodate through

schooling diverse ethnic and linguistic groups in the larger national culture. The feasibility of introducing to schools new technology (especially computers) for instruction and management also became a concern at this stage of the reform effort.

This "first wave" of school reform has now been overtaken by a further, and possibly more significant, "second wave" of reform. The new emphasis is on the need for significant restructuring of the organization and practices of schools as preconditions for any further significant change in education (AFT, 1987-88; Eisner, 1988; Elmore & McLaughlin, 1988). The role of the teacher in defining what happens in schools, how students are to be taught (and how teachers themselves are to be selected, educated, and certified), are the critical questions for second-wave reformers. Joseph McDonald (1988) described this second wave as the search for "the teacher's voice." The central issues involved might be characterized as follows:

Democratizing school administration. A key feature of the new proposals is building-based management of schools, under which teachers themselves play a significant role in management. The concept of "teacher leadership" appears frequently in these discussions (Barth, 1988; Sirotnik & Clark, 1988).

Teacher self-management and professional development. Teachers are to have an important role in making professional decisions. These include: selection of curricula, instructional materials, teaching approaches; decisions on research to be carried out; evaluation of peers both for entry into the profession and for merit and advancement; and design and implementation of further professional education (Lieberman, 1986; Shulman, 1987).

Altered classroom roles and emphasis on critical thinking skills. Teachers are demanding professionally significant changes in traditional classroom arrangements. These include many changes that technology can make possible—a change from being the source of knowledge to being a guide or coach to students; a change from frontal instruction to diversified classroom activities; and an expanded variety of instructional models and practices recognized as legitimate. One key aim of these practices is to increase students' abilities to reflect thoughtfully on what they have learned, not merely regurgitate facts (e.g., Sternberg, 1985; Tucker, 1985).

New modes of research on teaching and teacher preparation. These changes involve the role of colleges of education and their faculty. Colleges are to work more closely with teachers in defining teacher preparation courses; there is to be less emphasis on courses in pedagogical methods that do not meet teachers' practical needs (Holmes Group, 1986; Task Force, 1986). Faculty are to work directly with teachers in "professional development centers". Research should include anthropological study of classrooms and examinations of teachers' professional thought-in-action.

Educational Technology and Educational Reform

Teachers increasingly are demanding a larger say in how schools are organized and run. Assuming that teachers will not accept educational technology unequivocally and enthusiastically as either "new tools" or "systematic engineering," what role might there be for technologists either in supporting the reform of schooling or in providing useful data to policy makers? Several directions suggest themselves immediately: (1) preparation

of models of teaching-with-technology, (2) design of software, (3) creation of computer-based tools to support teachers' professional development, and (4) improvement of research. These are discussed below as an agenda for improving the use of technology in education.

Development of models of teaching-with-technology. Teachers' everyday classroom work involves great uncertainties regarding instructional methods and outcomes (Floden & Clark, 1988). Thus, teachers' models of teaching--mental images of how a classroom should look and feel, ideas about activities, ways of integrating instructional materials with lessons--are often less organized and less goal-oriented than technologists would prefer. Rather than try to supplant the models and practices that teachers have developed to cope with the uncertainties of their world, we should be trying to develop models of teaching-with-technology (in the sense of using tools, materials, and approaches) that recognize those problems, seek to alleviate their impact, and provide at the same time the opportunity for teachers to expand their thinking about what is possible in the classroom.

The first part of this task is therefore to understand better teachers' models of daily classroom activity, what place technology has in those models, and what meaning technology has in the context of the constraints and uncertainties with which teachers must deal. Part of this investigation of meanings must deal with the unconscious assumptions that teachers, students, and parents make about the role and value of technology in education, how successes or failures are ascribed to persons, materials, or approaches. Another part must probe teachers' motivations and sources of reward in teaching, and consider those in relation to what technology either provides or takes away.

Improved information about the realities of the teacher's world, about

the perceived role and value of teaching, of various teaching activities, and of the use of technology in teaching, can then feed the development of models of teaching-with-technology. Several desirable features of such models are clear: most importantly, they should accept the constraints under which teachers must work while they also expand the teacher's idea of what is feasible; they should reduce a teacher's burden of unrewarding classroom work (e.g., repetitive tutoring, grading exercises), buttress a teacher's position as guide and mentor for students, and demand minimal extra time for preparation; they should also be supported by appropriate prior training.

Unfortunately, creating and disseminating such models has been difficult. While there have been important demonstration projects that show what technology can do in selected classrooms (e.g., GTE's "Smart Classroom"; WICAT's Waterford School), these have usually focused on what can be done under optimal conditions, rather than on attempts to integrate technology-as-tools and technology-as-process into environments of typical schools and teachers. They have also routinely stressed the massive infusion of hardware plus a complex of software developed according to a single model of instruction. Teaching-with-technology requires more than a Stakhanovite approach to demonstrating what is possible. More important than demonstration centers or schools, in-service workshops, or summer institutes, are models that provide a well-articulated vision of how a particular approach can work in a real classroom (cf. other work on teaching models and how best to communicate them to teachers--Joyce & Weil, 1986; Weil and Joyce, 1978a, 1978b, 1978c).

One useful approach to the development of such models may be through the work currently being done at Stanford by Lee Shulman and his associates

in a project entitled "Knowledge Growth in a Profession." This work illuminates relationships among curriculum content, instructional strategies and approaches, and the underlying structure of disciplines. While those who train teachers and instructors often assume that there are many generic teaching strategies, the findings from this project suggest otherwise. Although there are indeed a few strategies that are general (included in what Shulman and his colleagues call "General Pedagogical Knowledge"), there is a larger set of information about instructional strategies that is linked directly to the structure of disciplines and the syntactic relationships among concepts and approaches in discipline-specific fields(Shulman, 1987).

Called "Pedagogical Content Knowledge," this information includes knowledge of students' understandings and misunderstandings, curricular knowledge, conceptions of how to teach the subject, and a subject-specific instructional repertoire. It may be that teachers' definitions of the place of technology in teaching (see, e.g., Grossman & Gudmundsdottir, 1987, on textbooks]) are intuitively more discipline specific than we have thought. If so, this needs to be discovered.

Development of supportive software. The large initial enthusiasm for the use of computers in education is now being tempered by a realization that software needs to provide more than intriguing games or electronic workbooks. There are two particular problems with instructional materials that are also related to the reform agenda, problems that educational technologists could profitably address.

First, there is the problem of how instructional materials are designed and tested. The changes inherent in school reform will require that technologists devote more time to initial needs assessment with teachers and that they put greater emphasis on user concerns throughout the process of

design. This need is now being effectively acknowledged by human-factors psychologists and cognitive scientists working on interface design for general-purpose and business software (e.g., Norman & Draper, 1986; Carroll & Rosson, 1987). A further requirement for software products will be a greater degree of teacher control and modifiability (see Hativa, 1986, for an example). Critical here is for educational technologists to move as far as possible away from the earlier concept of "teacher-proofing" materials.

A further useful approach is to provide teachers with programs that are instructive to both student and teacher (without being too obvious about addressing teachers), that support activities seen by the teacher to be clearly important. Pea and Kurland (1987), for example, offer a useful review of computer programs that may encourage development of writing ability. They maintain that the combination of directed planning, guided writing, and evaluation that the variety of writing programs now offer are close to a unified "cognitive technology." Authors of certain of the most successful pieces of recent computer instructional software (the Geometric Supposer, The Voyage of the Mimi) have maintained that these products have been consciously crafted to encourage learning on the part of teachers as well as students. Expansion of such efforts is at the heart of what needs to be done in order to make teaching-with-technology a reality.

Given the reform agenda, there are certain other approaches in designing and creating software that could usefully be exploited by educational technologists. One direction is the preparation of programs to allow more direct and regular interaction among students, and between teachers and students. New developments offer the possibility of enabling collaboration in ways not before feasible. While interesting work has been done to foster this kind of activity in joint writing or editing (Brown &

Newman, 1986), more could be done in other disciplines, especially to link technology with the current intense work to develop cooperative learning styles among students.

Programs that enhance motivation and excitement and the interest students have in learning are a further goal for technologists. Educational technology recently has paid too little attention to those practitioners whose original impetus for entering the field was to enhance students' motivation and interest. What is needed here is not unthinking use of game programs or entertainment software, but rather the creative incorporation of those elements of game design that engage students' capacities for fantasy, challenge, and creativity (Malone, 1981). Simulations that are open-ended and allow the student to construct meaning from a given situation (rather than building in the intended meaning, and assigning to the student the task of discovering it) are another goal for designers. Duckworth (1987) calls this approach "the having of wonderful ideas." Finally, there should be some attempt to create programs that strive for a "higher literacy" in the forms that new technologies make possible (e.g., Lee, 1985/86). Those concerned with ID need to recognize that there is value to openness as well as specificity.

Support for the education and further professional growth of teachers. It is a truism that teaching as an occupation needs to become more of a profession. In practice, this means improved education for teachers before they start their careers, and, once they have embarked on it, enhanced capability to manage their own work, to communicate with peers about common problems, and to improve practice through research and evaluation. Technology-based tools that encourage teacher professionalism could thus also make educational technology more useful to teachers in general.

Teacher training clearly needs to incorporate more information about and experience with educational technology, both hardware/software and process. But presenting these concepts in an isolated class (as is still required in many states) seems hardly the way to go. More useful in teacher education would be modeling of appropriate use of technology in general pre-service courses (both those in education and in the liberal arts), combined with placement as a student-teacher in a setting where the student teacher would encounter experienced teachers exemplary in their use of technology. While there have been calls for action (AACTE, 1987; Education, 1986; OTA, 1988), appropriate modeling of technology during teacher education is still much the exception rather than the norm. The new "professional development centers" called for in some reform proposals (to link schools, pre-service teacher education, and in-service training fro teachers) may be the places to provide experiences of this kind.

For practicing teachers, technology has already provided some useful lower-level software tools to enhance the professionalization of their position--spreadsheets for grading and assessment; word processors for routine administrative reports, letters to parents, and preparation of instructional materials; databases for keeping track of resources or student work. The problem here is more one of routine access than utility. A computer will not help in these tasks if the teacher must wait to use it, or if it is located inconveniently. Some school districts have successfully given computers to teachers to use at home, intending thus both to solve the problem of access and to aim for transfer of resulting skills to classrooms.

On a higher level, the impact of technology on teachers' professional work remains to be felt. Efforts have been made to encourage professional

interchange among teachers using bulletin board programs (e.g., Harvard ETC's Computer Conferencing Project--see Educational Technology, 1988). Teacher-oriented computer software to support collaborative evaluation and research are not yet common, but the flurry of interest in tools to aid computer-based collaborative work in business (e.g., DeSanctis & Gallupe, 1987) may lead to more interest in creating such programs for education.

Technological systems for gathering, collating, analyzing, and disseminating data about student performance could also help to make teachers' work more professional. Part of this process begins in teacher training, where students are not now commonly urged to become what Richard Elmore calls "voracious producers and consumers of information" about all aspects of school performance (personal communication, July, 1988). Neither are most teachers now given the opportunity to develop such skills in their daily life. In many school districts, student performance data are kept relatively secret not only to provide confidentiality for student records, but also to protect administrators and principals from potentially embarrassing inquiries regarding problems in teaching and learning, "disproportionality" in achievement by students from different SES or ethnic backgrounds, etc. Technology can break such barriers and improve the circulation of information both for the assessment of individual student needs and (more importantly) to allow teachers as professionals to "take the temperature" of the systems in which they work. Moving to such an information-based professional culture is not likely to be easy; it is a problem faced by many organizations under today's of rapidly spreading technology for creating and disseminating information on which management decisions can and must be made (see, for example, Zuboff's [1988] excellent treatment of such effects in industry).

Improvements in research on teaching-with-technology. Research on technology in education is improving, but many changes in both method and assumptions are necessary. There is now a strong consensus that technology-as-hardware does not enhance student learning (Clark, 1983). One needed approach is an emphasis on field experiments and a comparative examination of the application of technology in ways that are sensitive to differences in context (Becker, 1988). Others (e.g., Perelman, 1987) have urged an approach to research and evaluation regarding technology so as to encourage diversity among schools, and thus foster innovation and change instead of bureaucracy.

But these approaches, while desirable, leave pressing concerns of teachers unaddressed--the meaning of technology in their own day-to-day activity, the "look and feel" of classrooms in which teaching-with-technology has become the norm, and the internal habits of mind that teaching-with-technology imposes and encourages. While there have been some interesting studies (e.g., Olson, 1988; Parker, 1986; Wiske et al., 1988), much more needs to be done. This is the research agenda technologists must grapple with if they wish to take part in the second wave of the educational reform movement.

Several specific approaches could garner new information useful both to educational technologists and to policy makers concerned about how to implement technology-based programs. One needed new direction is increased emphasis on estimation of program feasibility. In a context where time demands on teachers and students are increasing, not decreasing, and where fiscal resources are limited, educational technologists are frequently called upon to estimate not just the costs of a program or the likelihood of its overall success, but rather the probability that it will make some

measurable and valuable contribution to the overall educational program of the school or district. Educational technologists should also be able to make reasonable estimates of time constraints and of the difficulty for teachers, students, and administrators of learning new systems and new approaches.

Also crucial is the need to move away from the present focus on measuring low-level, short-term cognitive outcomes and toward an approach in which long-term changes in cognitive style and personal well-being are assessed. The concerns that teachers, administrators, and parents have about the use of computers, for example, frequently have to do not only with immediate learning, but also with more general and long-lasting patterns of thought and action. Parents' fears that their children will develop to be computer "hackers" fall into this category, as do concerns about the longer-term impact of intensive use of computerized work environments, or of exposure to television (see, e.g., Ong, 1982; Meyrowitz, 1985; Palmer, 1989; Pool, 1983; and Turkle, 1984, on these trends).

Conclusion: Radical Reform and Teaching-with-Technology

Radical reform requires radically new ways of thinking about schooling. It demands that we recognize the importance of schools as social institutions, and of teachers as the agents principally responsible for effecting education. Using technology to define and strengthen teachers' roles, to empower them in their institutional context, to allow them to find and amplify their voice, will lead to a truer and more effective linkage of teaching and technology, a linkage that can also contribute to important broader changes now under way in education.

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