Instructional Technology and Teacher Education

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Abstract: In spite of Increased availability of technologies In the schools, their Im pact on instruction has been quite limited. Teacher education programs contribute to what happens In schools, and both levels of the educational system have been criticized for maintaining traditional patterns which are Inconsistent with what Is happening in the greater society. Several causes of the failure of schools to effectively utilize available technologies have been advanced, Including thefallure of teacher education programs to adequately prepare teachers to use technologies effectively. Potential solutions have been offered, although strategies for bringing thesolutlonstofulfillment are lacking. Most of the solutionssuggest adoption of an holistic process of instructional technology, reflecting three metaphors: tools, systematic, and systemic, in order to effect appropriate integration of available technologies and the curriculum.

Resume: Malgre la presence grandissante des nouvelles technologies dans les ecoles, rim pact de celles-ci sur la formation a jusqu'd present ete plut&t llmite. Les programmes de formation pedagogique y sont pour quelque chose. Les deux niveaux du systeme pedagogique ont ete mis en cause parce qu'ils malntiennent les modeles tradltlonnels en place alors que ceux-cl ne correspondent plus d ce qul se passe dans la societe en general.

Plusleurs ralsons peuvent expllquer pourquoi les ecoles utilisent mal les technologies disponlbles. Les programmes de formation pedagogique qui ne preparent pas convenablement les enselgnants sont en partle responsable de cette etat de chose. Certalnes solutions ont et6 proposees mals sans strategie d'appllcatlon. La plupart des solutions suggerent ('adoption d'un processus de formation technique global a trols volets : les outlls, la methode et le systeme - elements essentlels d l'integration des technologies disponibles au programmes d'etudes.

We live in a technological world. Our daily actions and thoughts are interwoven with the technologies with which we come into contact. Technologies are not neutral and neither are people. We are influenced by technologies, but we in turn have the power to regulate what they do to us.

There is much uncertainty over the meaning *of technology*. When the term is accompanied by an antecedent such as *instructional,* the meaning becomes even less clear. Instructional technology, as it is addressed here, refers to a

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process involving appropriate techniques to bring about effective instruction in order to facilitate desired learning outcomes. All the people and/or machines involved in the process are a part of it. Instructional technology as a process is not inherently narrow and mechanistic. In fact it has been suggested that the broader, but closely related construct, educational technology evokes three constantly shifting metaphors (Davies, 1973; Hlynka& Nelson, 1985). The three metaphors are related to implicit structures which help to define the nature of educational technology: "At one point, teachers as technologists function within the tools metaphor. At another time the same teachers may function systematically while, at a third point, the systemic, gestaltic, and aesthetic metaphor gains control" (Hlynka & Nelson, 1985, p. 13).

Instructional technology is often inappropriately considered to represent only the tools metaphor. In fact, instructional technology is sometimes equated only with using computers for instruction. However, microcomputers and their related courseware, as well as the many technologies which facilitate learning by providing a wealth of pictorial material would be best described as technologies for instruction.

The systematic metaphor is associated with contemporary practices in the field of instructional design. A product of the industrial machine age, and closely related to systems engineering, the instructional systems design model has been criticized for its emphasis on fixed objectives and for being a deterministic, closed system. Still, it represents a flexible framework which is capable of accommodating a variety of learning theories in decision-oriented instructional contexts (Dick, 1991).

A systemic, holistic view of educational technology, which is less mechanistic, and more humanistic, emancipatory, and organic has only recently begun to evolve. Although not fully clarified at the moment, the construct is rapidly gaining momentum (Balaban, 1990; Melton, 1990; Nichols, 1990). Banathy (1987, 1991) has proposed a broad "macro-systemic" orientation, the purpose of which is to view school settings as complex, open, and dynamic systems that are in constant interaction with their environment (the societal system).

If we agree that technology's role in education has not been totally defined nor widely accepted by educators, why consider using technologies in education in the first place? Although the residue of over 50 years of research would seem to be conclusive at first glance, considerable skepticism has been advanced relative to whether the technologies (media) used for instructional delivery actually make a difference (Clark, 1983; Clark & Salomon, 1987; Clark & Sugrue, 1988). The argument that any medium is equally effective when the instruction presented is equivalent across media is difficult to reject, but is not just cause for suggesting that technologies are not required in education. Other conclusions may be derived from the research, most notably the persistent finding that where significant outcomes favored a technological delivery system, highly effective planning took place.

The expansion of technology in education during slightly more than a decade has been described as "rapid and chaotic" (AACTE Task Force on Technology,

1987, p. 25), with "unprecedented growth in the amount of technology available in schools" (Glenn & Carrier, 1989, p. 7). Still, a major government report in the United States, while documenting and projecting the number of microcomputers in the schools to well over 2,000,000, concludes that "few teachers have found ways to exploit the enormous potential which interactive technologies offer" (United States Congress Office of Technology Assessment, 1988, p. 87).

Public schools are constantly being asked to respond to a growing list of society's needs and concerns. At the same time critics are calling for more quality and more rigor for all students (Glenn & Carrier, 1989). Further, the critics point out that schools have failed to keep up with the times:

> Inside and out, schools today look very much the way they did a hundred years ago: the buildings, the size and shape of classrooms, the divisions based on age, and the ways of "delivering" instruction have changed very little. Yet the world has changed remarkably. Families, jobs, social organizations, and entertainment look nothing like they did at the turn of the century. From inside a school, however, one would hardly know that visual images, rapid motion, technology, and change are pervasive in the world outside. (David, 1991, p. 37)

We are constantly aware of the rapid influx of technology and we recognize that significant change is taking place in society. We speak of change, but what really is new? A statement first published nearly 40 years ago suggests: "What is new is that in one generation our knowledge of the natural world engulfs, upsets, and complements all knowledge of the natural world before" (Oppenheimer, in Bennis, Benne, Chin, & Corey, 1976, p. 1). Thus our mission is to recognize the change, learn what resources we have, and try to use the available resources in appropriate ways.

"FAILURE" OF SCHOOLS TO EFFECTIVELY USE TECHNOLOGIES

Why have schools failed to take optimal advantage of technologies for instruction? What's wrong? What factors have contributed to this apparent failure? There is a lack of universal agreement, and some of the causes which are advanced below may tend to contradict others. It must also be noted that a "tools" metaphor tends to dominate in the following summary of viewpoints which have recently been advanced in North America:

- Schools are purchasing more hardware, but the impact on classroom instruction is at best negligible. Computers remain a neglected resource within our schools (Futrell, 1989). The vast majority of schools still do not have sufficient numbers of computers to make them an integral part of the instructional process (Glenn & Carrier, 1989).

- It has been claimed that the vast majority of teachers have little or no training in the use of technology (Glenn & Carrier, 1989). Even when new teachers have been taught to use computers, they usually have not been taught how to *teach* with computers (Futrell, 1989).
- If a technology (the computer) plays no role in academic courses, it is unlikely to have much total effect on the educational system. When the question of what technology should be used is driven by the latest piece of equipment, rather than by pedagogical considerations, there is a complete lack of curriculum and learning consideration. "Decisions made without taking into account the full learning context are likely not to be adequate decisions" (Bork, 1991, p. 362).
- School leaders often lack understanding of the products and processes of instructional technology. Thus, they have difficulty in providing support to teachers and staff which can assure the desirable use of technologies in their schools (Bitter & Yohe, 1989).
- The computer literacy movement, with its emphasis on programming resulted in many years of relatively wasted effort (Marker & Ehman, 1989). Research has demonstrated that programming does not increase problem solving capabilities. Teaching programming represents limited use of the computer in education, and student time might better be devoted to other purposes (Bork, 1991).
- While many teacher education programs and school districts have inservice programs on effective instructional strategies and using technology, seldom do they bring them together (Futrell, 1989). In particular, beginning teachers are bitter because of the lack of connection between what aspiring teachers are exposed to through teacher preparation curricula and what they encounter in their classrooms (Glenn & Carrier, 1989).
- An erroneous assumption is that the computer is an entity in and of itself, and thus deserves a special "laboratory," a special curriculum, and a special teacher to teach it. What might have initially been a well intended idea, albeit ill-founded, has become a roadblock to change (Salomon, 1990).

The same criticism might well be extended to include the sanctification of the classroom "box" model of instruction in the schools.

Finally, an aspect of the problem seems to be that we seldom make effective use of the "tool" technologies that we have. We seem all too eager to proceed to newer delivery systems, even when we have had limited success with available technologies. This is obviously the case with schools and teacher education programs alike, and the two are closely linked, even though the level of collaborative effort is frequently low. Since teacher education programs are responsible for preparing the present and future complement of teachers, we now examine factors in those programs which may have contributed to the failure of schools to use all available resources in the most appropriate manner.

TEACHER EDUCATION PROGRAMS AND THEIR CONTRIBUTION TO 'TAILURE"

There is widespread agreement that if schools are to use new and emerging technologies to improve the quality of schooling, teacher education programs will need to make a major contribution (AACTE Task Force on Technology, 1987; Bitter & Yohe, 1989; Futrell, 1989; Cooler, 1989; Harrington, 1991; OTA, 1988). Teacher education programs must be considered an integral component of the entire societal landscape. We now focus on teacher education programs and their influence, drawing primarily on recent North American perspectives of the situation.

As long as the university remains the primary gatekeeper for preparing new teachers, the content of preparation programs for teachers will largely be determined, for better or worse, by professors who teach teachers. However, many teacher educators are not prepared to use technology effectively in their courses (this includes older technologies as well as emerging interactive technologies). The bulk of faculty currently engaged in teacher preparation were themselves not prepared to use technologies, nor have most kept current with technological developments. Unfortunately, structural issues such as how things should be taught, by whom, on who's turf, etc., represent potential barriers to effective teaching about technologies for instruction in teacher education programs (Cooler, 1989).

Teacher education programs continue to suffer from "congenital prestige deprivation" and their fundamental structure remains largely unchanged, as many "programs remain wed to entrenched orthodoxies and mired in an organizational time warp" (Futrell, 1989, p. 45).

Such obsolete programs present an increasing problem for teacher educators as they struggle to keep pace with changes taking place in the public schools. Few models of instruction currently exist to assist in providing delivery systems necessary to prepare prospective educators for successfully using technology (Marker & Ehman, 1989). Contemporary teacher education programs tend not to advocate a process of instructional technology as a planning procedure.

Minimal exposure to technologies in their preparation programs make it highly unlikely that most graduates of teacher education programs will develop interests in and facility with technologies once they are teaching in their own classroom. In general, most teacher education programs have limited access to adequate hardware and software with which to prepare would-be teachers (Cooler, 1989). Bork argues even more vigorously that teachers now coming out of schools of education have almost zero acquaintance with computers, because very few schools of education anywhere in the world are in a position to deal with this question adequately. He concludes that teacher education will not be successful until we have adequate curriculum material using the technology, at which point we will also need good materials for training the teachers to use these technology-based courses (Bork, 1991).

While teacher education continues to be one of the most critical components in the success of any instructional technology program, inservice activities provided by school districts must play a critical role in the process.

Sturdivant (1989) summarized some of the commonly acknowledged obstacles faced by school systems embarking on inservice teacher education for instructional technology:

- incentives are lacking for further training;
- teachers who take additional training are often unrecognized;
- amount of paperwork, leaves little time for staff development;
- teachers have limited opportunities to see model applications;
- teachers are isolated and have few opportunities for sharing;
- access to software is limited; and
- teachers still don't have enough computer access.

Sturdivant reported initiatives undertaken by her school system which showed that some progress had been gained in overcoming the obstacles. She then concluded that the first and potentially most destructive problem is staff turnover. There is a great demand in business and industry for good corporate trainers. Consequently, articulate and well organized teachers who understand instructional design and who know how to use technology effectively are likely to leave the profession for greener pastures.

USING TECHNOLOGY TO DELIVER THE TEACHER EDUCATION CURRICULUM

Brooks and Kopp (1989) argued that if teacher education is to meet its responsibility to prepare teachers for the information age, then teacher educators have a professional responsibility to provide leadership in developing the full potential of existing and emergent technologies in teacher education programs. They noted a lack of planning, coordination, direction, and support of research on the applications of technology to teacher education. Six significant contributing factors were identified:

- absence of coherence in preservice program design;
- the semantics of technology;
- funding priorities;
- costs;
- limited faculty development; and
- a lack of research on the impact of technology on teacher education.

In a review of research studies reporting technological treatment effects that improved teacher training, Brooks and Kopp (1990) identified 42 of 72 studies with the program theme "Demonstrates a Repertoire of Appropriate Teacher

Skills and Behaviors". With few exceptions the studies reviewed focused on the discrete technical skills of teaching. Program themes such as "Designs instructional methodology in media and technology appropriate to goals and objectives", and "Uses appropriate instructional materials, media, and technology" were lightly represented, even though they might arguably evoke better transfer toward the goal of effective utilization of technology in schools.

Many projects devoted to the use of technology in teacher education programs have involved mammoth outlays of financial and human resources to perpetuate the status quo, which is to say an emphasis on teaching behavior. Such projects stress, as do teacher education programs in general, interpersonal communication between the teacher and individual students. In reality the communication in most classrooms more often resembles mass communication. A number of exemplary projects focusing on other program themes were reviewed by Brooks and Kopp, and others are ongoing throughout North America and elsewhere. However, to emphasize the point of possible misdirection of priorities, we now review some projects which focus on the discrete technical performance of teachers.

Typical of such studies is one reported by the Iowa State University College of Education (1988). The electronic technology used was interactive videotapes. Emphasis was placed on developing sensitivity to several fundamental teaching behaviors, with an objective of building the skill of observation and assessment of teaching behavior. The improved writing ability of students indicated a gain in the use of technical terminology and sensitivity toward examples of effective and ineffective classroom teaching behaviors.

A program was developed at Utah State University using instructor-controlled videodiscs (Salzberg, Rule, Chen, Fodor-Davis & Morgan, 1989). The thrust was to provide training opportunities for staff in rural and remote areas who deal with students having low incidence handicaps. Included is the presentation of a five-step teaching sequence to assure that trainees will learn to carefully monitor student responses, reinforce accurate performance and correct errors. Other units introduce presenting information, motivating pupils, and solving problems. The investigators acknowledge that a key limitation of the system is that trainees' responses within the system are primarily verbal.

In reaction to the behavioral emphasis in developmental studies of the type just described, Copeland (1989) proposed the development of pre-student teaching laboratory experiences intended to assist novice teachers in the development of their *clinical reasoning* (thought processes that precede purposeful teacher action). The proposed simulation would be based on an empirically derived model reflecting the typical patterns of teaching and learning behavior that might occur in classrooms. Although the system would depart conceptually from earlier approaches by deriving its underlying assumptions from cognitive rather than behavioral psychology, preservice teachers would still be prepared for an historic world which reflects little or no suggestion of utilizing resources other than the teacher.

Two extensive projects reflecting the essence of Copeland's suggestion are worthy of note. The initial phase of a long-term project undertaken by Cleveland State University, (Azbell & Patterson, 1988) involved development of interactive videodisc technology intended to provide student teachers with practice in using a problem-based model of instruction to acquire the skills needed in the application of diagnostic/prescriptive reading techniques in the classroom. A project being developed at Michigan State University (Lampert & Ball, 1990) uses interactive video and CD ROM technology to enable prospective teachers to examine and interact with lessons taught by experienced teachers in authentic mathematical activity in school settings. The investigators propose that this will enable students to form their own hypotheses about teaching and learning, and to test those hypotheses against the wealth of data from the classrooms. It is tempting to contrast the detailed methodology of analysis which this project presumably requires to that used by developers of Intelligent Computer Assisted Instruction (ICAI) and expert systems.

A series of videodiscs has been developed by the Faculty of Education at the University of Alberta (Engel & Campbell-Bonar, 1989) to allow preservice teachers to formulate and explore classroom management strategies in a non-threatening setting. One disc, Classroom Management: A Case Study is designed to encourage beginning teachers to take a problem-solving approach to understanding one student's personal experiences and motivations and their effect on classroom and social behavior. Student involvement with the disc simulates teacher activity which could well take place over a period of days, or even weeks. However, another disc in the series, "Do I Ask Effective Questions? or, I Can Hardly Wait to Hear What I'll Ask Next!" (Campbell-Bonar & Grisdale, 1991), is once again based on the historic model of immediate teacher-student classroom interaction.

Despite the exemplary scholarship inherent in the majority of the developmental investigations sampled above, one is forced to contemplate the existence of "rear-view mirror" syndrome, as described by Marshall McLuhan (McLuhan & Fiore, 1967) in contemporary teacher education programs. "The past went that-a-way. When faced with a totally new situation, we tend always to attach ourselves to the objects, to the flavor of the most recent past. We look at the present through a rear-view mirror. We march backwards into the future" (pp. 74-75). On the whole the projects reviewed appear to do little to prepare prospective teachers for non-threatening, creative environments which encourage effective use of all available learning resources.

PROPOSED SOLUTIONS

Some recent proposals toward appropriate integration of technologies in schools and teacher education programs are summarized below. A limitation is that the proposals tend to lack suggestions for strategies which would involve the many diverse groups whose support would be necessary in order to make the

plans operational. On a more positive note, if we examine the "solutions" collectively, a case could be made that adoption of an organic, humanistic instructional technology process is necessary if electronic technologies are to be effectively utilized to assist schools at all levels of education in accomplishing their mandate.

A "Whole Course" Approach

Bork (1989,1991) argues that the only way interactive information technologies can be used effectively in education at all levels is to develop entirely new courses in a variety of curriculum areas. The full potential of interactive learning technology cannot be realized without newly designed academic courses. Teacher education must be associated with each of the new courses developed, and the development of materials for teachers must be considered an integral part of the development of the courses. With the focus on full course development, "we can rebuild schools and universities with technology-based courses that were not possible with older technologies" (Bork, 1991, p. 379).

Instructional Technology: Tools; Systematic; and Systemic

Widespread changes will be required in order for available technologies to become effective tools for regular classroom activities, not just as add-ons to be studied and learned about. The role of computer laboratories in schools might well be reconsidered, if, as Salomon (1990) suggests they have become self-sustaining, entrenched, and taken-for-granted bases of power. The entire classroom structure needs to change in a way that makes curriculum, student learning activities, teacher behavior, social interactions, learning goals, and evaluation interwoven into a whole newly orchestrated learning environment. Certainly a desirable strategy to bring about the most effective use of technologies in education at all levels would be to to utilize the tools, systematic, and systemic metaphors of instructional technology as appropriate, on a school-wide and system-wide basis.

Teacher education programs might well consider the same approach. Based on the assumption that most preservice and inservice teacher education programs have not come to grips with what it is that they should be trying to accomplish, Brooks and Kopp (1989) suggest a systemic approach, combined with creative planning, to the design of teacher education programs. Teacher education programs must take the initiative in developing greater collaboration with the schools, professional teacher organizations and government agencies. Research and development within teacher education programs might also profit by initiating more projects which incorporate technologies to demonstrate the emerging role of teachers when using learning technologies, rather than introducing technologies as artifacts of study, or to promote a "rear-view mirror" approach to classroom activity.

Technology Integration for Mcdnstreamed Students: A Side Door Approach

The current North American phenomenon of *mainstreaming* or *integration* could ultimately provide a link for successful technology integration in the schools. The use of computers has reinforced the importance of individualized learning and has broadened opportunities for educators to provide equal educational opportunities, not only for students with special needs, but for all students (Wilson, Casella, & Wilson, 1989). Studies of research to improve the integration of technology to assist handicapped students in mainstreamed classrooms suggest that the entire school system needs to commit to using technology to deliver the curriculum and to develop and nurture academic skills at successive grade levels (Anderson, 1990-91). Of special significance are the following conclusions:

- successful computer lessons require the correlation of the software used with curriculum objectives and student needs;
- regular and special education teachers need to be actively involved with students' use of all types of software;
- teachers need opportunities to continually reflect on and to evaluate practice; and
- teachers need to draw on knowledge about students in relation to the potential contribution technology can make to curriculum and instruction.

Active Learning, Technology, and Restructuring - Synergy?

The potential synergy which might be accomplished through the integration of three contemporary thrusts is intriguing. Increasingly, educators and policy makers are recognizing the critical need to produce students who know how to think, who understand concepts and ideas, and who can apply what they learn, pose questions, and solve problems. This is accompanied by calls throughout North America for *restructuring* of schools in fundamental ways. Restructuring can provide a framework for changing the system as a whole, and thus create an environment within which particular reforms can be carried out successfully (Fullan & Miles, 1992; Norris & Reigeluth, 1991;Sheingold, 1991). As indicated earlier, the use of technology in schools is not presently tied directly to the improvement of learning on a large scale, and the full potential of the technologies is not being widely realized. Still, it seems unlikely that such ambitioua goals for learning and teaching can be met, unless accompanied by widespread, creative, and well-integrated uses of all available technologies, deeply integrated into the purposes and activities of the classroom. But the synergy can only happen if it is a system wide process. We cannot expect to see individual classrooms and schools change substantially if the other pieces of the system do not also change (David, 1991).

Echoes From the Past

If much of the preceding sounds familiar it probably is. The decades of the 1950s and 1960s generated a great deal of excitement related to mediated learning resources. We discovered that "In order to produce a good film, one must first make a correct analysis of the teaching task" (Miller, 1957, p. 14). We were reminded that it is easy to get the technology ahead of the objective but that: 'The better approach is to try to locate the fundamental educational problems (which certainly are acute!) and then to see how new techniques can help solve them...The emphasis must be not on the technique, but on the goals of education" (Miller, 1957, pp. 32-33). Miller, among others, also reminded us that in addition to examining the content of the curriculum, we should take a new look at the entire educational process, and that without fundamental new thinking we would be unable to solve the "crisis in education".

Later, William Clark Trow (1963) provided an outline for a "systems" environment as an approach for schools to gain optimal advantage when using the "new media". Trow's plan did provide a fundamental new way of thinking, and while it has not gained widespread acceptance in the education community, many of his suggestions are echoed in the "solution" proposals for the 1990s which we reviewed above:

> The question that faces educators today is not how any one of these instructional media can best be used in the schools as they now are, but rather, how they can best be fitted together, along with the school personnel, all to become not aids or adjuncts but components in an educational system. This is something more than training teachers to employ the new media-use the tools and operate the machines. The new technology requires that man [people] learn to cooperate with the machines. He [They] must know what each component can do, and so fit them into subsystems within the larger system. (Trow, 1963, p. 116)

Thus, the obvious task would be to coordinate and integrate available technologies as components and subsystems in a unified pattern of procedures, with the overall goal of enabling students to achieve desired instructional outcomes. Under such a system, Trow argued that there was little chance that teachers would suffer from technological unemployment, but stressed the necessity for a greater degree of role differentiation. Under Trow's plan the functions of school personnel would differ widely, as would the personalities and perceptions required for the various functions. But the staff functions would be performed by people, and Trow insisted that the schools could not and would not be dehumanized by the introduction of better technology.

SUMMARY

So what have we learned? Teacher education programs have been involved with "new", "newer", and "emerging" technologies for at least five decades, and

there have been many impressive examples of effective utilization and integration of technologies, both in the schools and in teacher education programs. Still, there is nearly universal agreement that many technologies which have been quite successful in society have had only limited impact on the educational environment, particularly relative to instruction and the instructional process. Causes of "failure" have been frequently documented and some attractive solutions have been proposed, most of which implicitly suggest an instructional technology process, involving a synergistic combination of tool, systematic, and systemic approaches. The challenge remains to devise strategies which can unify the many divergent elements in order to bring about actual, not merely proposed, solutions.

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