

Teacher Development: The Implications of Using Computers in Education

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The development of computer literacy among teachers requires pre-service education, in-service training, and graduate education. These methods would be more effective if based on an analysis of computers as communications media, and on the assessed needs of teachers. Curriculum-based and iterative needs assessment would provide continuous guidance in professional development work, suggest implementation strategies, and inform the relationship between teachers and innovation.

Le perfectionnement des enseignants en informatique exige la mise sur pied de cours de premier cycle, de séances de formation pratique et de cours de deuxième et de troisième cycles. Le perfectionnement en informatique serait plus efficace s'il se fondait sur une analyse des ordinateurs comme médias de communications et sur l'évaluation des besoins des enseignants. Une évaluation en fonction des programmes et des besoins les plus courants permettrait d'orienter comme il se doit le perfectionnement des maîtres, de suggérer des stratégies d'implantation et d'optimiser le rapport enseignants-innovation.

Writers on teachers and computers in schools often argue that "To breed the confidence in handling computers which is essential if they are to use them inventively and to encourage children to experiment a large scale campaign of in-service education is essential" (Megarry, 1983, p. 25). A British teachers' union leader called, in 1982, for a year's crash course of in-service for primary teachers. The Association for Computing Machinery education board, with two other ACM groups, published a report on the topic of teacher training in 1983. The Ontario government has established a series of three courses on the topic of "computers in the classroom." The question of who shall be educated, by what means, and to what ends, still arouses disagreement.

The phrase "teacher training" does not describe the development process. Gary Boyd brought this forcefully to my attention, but it is essentially the same point Weizenbaum (1976/1984) made, inspired by Smith (1975). Weizenbaum thought that it would diminish both himself and his profession to think of himself as providing only training in computer science. An emphasis on training would separate him from the intellectual and moral

life of the university. Teachers must not acquire computer skill training without moral and intellectual foundations.

THE DEVELOPING PROBLEM

Computer Literacy

Often this question is put in terms of “computer literacy” requirements. The assertion that students should be computer literate commonly leads to the claim that teachers should also be, if only to be able to teach computer literacy. Since the term “computer literacy” has no agreed definition, these claims cannot be assessed. Most might agree that computer skills and knowledge could be useful to students, in their current and future studies, and in their lives after formal schooling, but would be unable to agree on just how.

This paper emphasizes teacher development and ignores the literature on the definition and implementation of computer literacy. *En passant*, it may implicitly define computer literacy.

Sources of Teacher Motivation

Computers have frequently entered the classroom at the teacher’s invitation. Teachers who began to use computers because of their own personal interest were willing to invest huge amounts of their own time, money, and energy (both physical and mental) to implement computer activities in their classrooms. If we base our expectations on the achievements of those who “love” computers, the development process becomes more difficult. Many teachers see the suggested applications of computers and the associated training demands, as quite unrealistic. Consequently, Eggers and Wedman (1984) refer to teachers as a bigger threat to computers than computers are to teachers.

Lack of Formal Training

Computer-using teachers select themselves and thus often lack formal computer training as well as pedagogical and evaluation skills. We would be impressed if teachers could teach their dogs to speak, but wouldn’t necessarily assume the dogs had something important to say to students. Teachers who create their own computer applications are often so caught up in the thrill of accomplishing a difficult task that they lose their critical evaluation skills, reinforcing other teachers’ negative perceptions about computers in education.

Multiple Roles of Computers in Education

Computers play more and more roles in education and society, but we talk about “the computer” as though it had only one application. One reason for this is that some people only see the computer (and programming) as an object of study, others think the delivery of instruction is most important, an increasing number believe the use of computers as tools in all discipline areas is most important, and so on. As long as these narrower views are vigorously proposed, teachers will be confused about their own development.

The Values Factor

Values considerations override all the preceding issues. That is, the particular computer applications we choose are a function of our values, but not only that. It is also true that the use of computers, just as television or automobiles, can change our values. Just as the automobile has altered our valuing of “the neighbourhood” or the “nuclear family,” so it appears computers may affect the valuing of communication. In word processing, writers spend more time on composing and polishing memos; electronic mail leads to more informality, sometimes called “flaming language” (Kiesler, Siegel, & McGuire, 1984).

The values component is seldom given explicit mention, but often determines why people support or reject computers in general, or particular applications.

Pre-Service Education

Pre-service teacher education offers a number of obvious advantages, but also drawbacks. Advantages include clear definition of those to be trained, their relative homogeneity, and their availability for this purpose alone for a defined period of time.

Collis and Muir (1986) found 43 (of 49) Canadian faculties of education providing 260 undergraduate courses on computer topics, but with considerable diversity in content and sequence. Course sequences for computer-using educators were rare.

Because of the emphasis on one-year B.Ed. programs in Canada, the task of finding time for new material in a full curriculum takes on greater importance. Even if time can be found, the implementation of training poses problems of resources, particularly equipment and staff. Equipment is probably the lesser of those worries, since the cost of computing equipment is declining. This may be a misleading judgment, since the cost of computer software can easily offset savings realized through hardware cost reductions.

Even if money were freely available, the problem of staffing would remain. The easiest and most direct answer is to create and staff new courses on educational applications of computers. Unfortunately, new courses are less satisfactory than integration of computer techniques and applications into the curriculum of schools of education. The problem of pre-service training thus becomes a problem of in-service training, since the faculty of the school of education must acquire the new computer skills for integration into their courses.

In-Service Training

The problems of in-service education are much the reverse of those in the pre-service setting. Teachers are less homogeneous and have less time to spare, but they have teaching experience and are likely to teach for some considerable period of time.

Equipment problems continue to plague in-service education, though increasing numbers of school boards have set aside special facilities. School computer equipment is usually in high demand, not only throughout the day, but often for night and weekend classes as well. Teachers often have difficulty obtaining access to computers outside in-service course hours, or no access at all once the course has ended.

Staffing problems take on a similar form. Locating instructors who are not male, math or science teachers, and uncritical computer enthusiasts can be difficult. Moreover, because of their special abilities, they are often over-worked and consequently not available for consultation outside of class hours or, and most important, after the course has finished.

Graduate Education

Graduate programs should not be an alternative to pre-service or in-service courses, but may have been "diluted" because they were seen to be alternatives. Collis and Muir (1986) found twenty Canadian institutions offering 85 graduate courses on computers in education, but this may overestimate the graduate content. For example, some institutions have given graduate credit to teachers taking courses in BASIC programming. The role of graduate programs should not focus on the "how-to" questions of computer applications, but rather delve more deeply into the "why," "when," and other related issues.

Research Directions

Gottfredson (1984) describes a process designed to combine question definition and answering, a "program development evaluation approach."

He emphasizes strong collaboration between the researchers and the implementers of the new program. Teachers are usually implementers of new computers-in-education techniques, but are rarely active as researchers.

Teachers are in an ideal position to identify the unintended outcomes of computer use, but are not always prepared to look for them. With greater sensitivity to side effects, teachers can help identify research questions, obtain some direct answers, and through systematic information exchange, decrease the need for "training courses." (In a current research project, I am working with a group of "teacher researchers.")

THE MISSING FOUNDATIONS

Computers as Communications Media

Side effects are a major worry because the effects of communications media, of which the computer is one, are so difficult to predict (Lias, 1982). If the most important effects of computers are hidden and if applications themselves are not clear, how do we prepare teachers to deal with the unknown effects of unspecified applications? Building courses on the hopes of computer devotees is *not* the answer. In fact, we must question seriously the assumption that computers in general, or any computer application in particular, must by definition have positive effects that outweigh all negative effects.

Needs Assessment

Needs assessment is often limited to considerations of technology, rather than examining the needs of students and teachers. On the other hand, needs assessment is not a clear-cut, uncomplicated process. The definition of "need" itself is in dispute, the determination of needs is usually subjective, and the entire process of assessing and meeting needs is heavily influenced by values (Scriven & Roth, 1978; Krathwohl, 1980; Guba & Lincoln, 1982; Lincoln & Guba, 1985).

I deal with needs assessment as I do with side effects. Side effects, although obscure, are clearly worth evaluating. Similarly, rather than propose a technique or strategy, I wish to stress the importance of needs and their assessment, and merely outline procedures.

A PLAN FOR DETERMINING TEACHER DEVELOPMENT REQUIREMENTS

Determining Educational Goals

It is assumed that the definition of educational goals will precede the consideration of computer applications. It is desirable that the process of

definition begin with the underlying values of the population, using these to develop an educational philosophy that incorporates the "absolutes" of the educational system, providing a solid foundation for the steps that follow. If inconsistencies exist, such as the values demanding adherence to a moral code while the philosophy would have students develop their own moral code, the remainder of the process may be only speculation.

The foundation of educational goals lies outside of the schools, but the study of computers is perhaps too strongly influenced by answers to the question, "What computer skills do graduates need in order to succeed in the business or university world?" Unfortunately, some educators assume that the mandatory purchase and use of a computer (required in some universities) implies the same length of preparation as would the mandatory purchase and use of a piano.

Politics may also lead to conflicting goals. For example, in the French plan, "Informatique pour tous," almost all of the first 120,000 microcomputers for schools are from French firms, although the French microcomputer market is dominated by U.S. and British companies (Etheridge, 1985). That is, support for French industry is more important than preparing students for the business world. Similarly, in Ontario, a government fund for "industrial development" financed initial software and hardware development for Ontario schools, emphasizing purchase of Canadian products.

Determining Curriculum Objectives

Curriculum might be defined as problem solving, transforming the original state of the student (entering the school system at age 6, and so on) into the desired state. However, to look at curriculum definition only in this way is to emphasize external demands (product) and to underestimate internal demands (process). Introduction of a new element in the curriculum may appear an isolated change, but have broad consequences. For example, teachers often reduce the time allocated to the traditional curriculum to introduce computer literacy (Carmichael et al., 1985; Eaton & Olson, 1985; Olson, 1988).

Assessing the Needs

I assume now that some school(s) has defined goals and objectives, but has not determined how computers are to help meet the objectives, nor what skills teachers will need, nor how they are to acquire them. I begin with a definition of the ways in which computers will be used in schools. A consensus of specifications does not exist, particularly in terms of grade and subject matter combinations, so the following discussion will be general and

based on a set of three broad categories of computer uses in education: teaching *about* computers, teaching *through* computers, and teaching *with* computers (Ragsdale, 1982).

Instruction *about* computers ranges from the earliest introduction of computer concepts to the preparation of sophisticated programs and can be subdivided into three parts: pre-computer instruction, development of skills for computer users, and programming.

Pre-computer instruction includes systematic planning and problem solving, the study of the impact of computers on people, the identification of computer uses, and so on. The development of user skills is extremely dependent on context. Where students use word processors, they must be prepared for this specific task, and as other relevant applications become available for student use, the appropriate instruction must be supplied.

Programming skills may be acquired at early grade levels, though not always as an objective of the school. The important point is that programming, at any level, should be based on its important conceptual aspects, not seen as a casual activity.

Instruction may be spread over a number of years, thus reducing teacher load. Further, peer-tutoring may accomplish much instruction about computers. Bitter and Camuse (1984) describe a plan that allocates computer activities to grades K–12, including an emphasis on student cooperative work and peer tutoring.

Teaching *through* computers is the use of computers to present instructional material, along with associated diagnostic testing, often called Computer-Assisted Instruction (CAI). When CAI materials are properly developed, the teacher need have little knowledge about computers. Unfortunately, little CAI is properly developed, and teachers attempting CAI want to modify the programs or even write their own programs. Teachers creating their own CAI frequently become frustrated by the size and complexity of the task.

Teaching *with* computers refers to the use of computers as tools for studying other content. In these applications, such as word processing, information retrieval, and music composing programs, students are not only able to complete tasks more rapidly, but are often able to do things (transpose a melody) they might not have attempted without computer assistance. Many tool applications are independent of subject matter and can be used across subject as well as grade levels.

Teachers should know the skills that the tool programs require and produce, but need not be expert users. The greatest challenge to the teacher will be to use effectively the new skills that students acquire.

Given these broad categories of educational computer use, what com-

puter assistance might benefit students and teachers seeking to satisfy the requirements of the curriculum? One might ask "What is the greatest obstacle to students becoming creative writers?" or "What is the most important factor impairing the physical fitness of high school graduates?" or "What is most important in preventing 8-year-olds from gaining a proper grasp of elementary mathematics concepts?" The focus *must* be on humans needs rather than machines. That is, we are not asking "How can the computer help . . ." but rather "What do students (and teachers) require in order to achieve what the curriculum has defined?"

A second important feature of the needs assessment is that it be iterative, to identify the new needs which arise as the result of satisfying earlier needs. For example, if I were given a typewriter on the basis of an earlier needs assessment, the use of it might bring to light a serious deficiency in spelling, previously hidden through my judicious use of ambiguous scrawling.

This step is meant to include *all* teachers. The goal is to identify all instructional problems, not to restrict problems to those encountered by teachers as a result of using computers.

Changes in Curriculum Objectives

One possible outcome of the previous step is that curriculum objectives would be changed. For example, the failure of 8-year olds to achieve their mathematics objectives might lead to new content or processes (such as Logo) designed to facilitate the learning (such as geometry concepts).

Changes in process for one part of the curriculum can mean changes in content for other parts of the curriculum. A decision to apply word processing in creative writing implies that students will somehow learn the content of "how to use word processing." It is tempting, but dangerous to ignore content changes or equally crucial attitudinal changes that accompany successful implementation of new content.

IMPLEMENTATION STRATEGIES

Once student and teacher needs have been cast in the form of a general curriculum solution, the consideration of specific solutions can be considered. Using the questions preceding, let us assume that more physical activity outside of school is seen as the solution to the physical fitness question, an increase in review and practice is the solution for the mathematics question, and an increase in the amount of student writing is seen as the solution to the creative writing problem.

To the computer enthusiast, the question is "How can we use computers

to achieve our aims?" Instead, we must develop, as creatively and exhaustively as possible, a list of "critical competitors" for the role of possible solution. Scriven (1981) speaks of "critical competitors" (alternatives which must be compared with the program or product being evaluated) in discussing product evaluation.

In considering our three examples we will use a limited list of critical competitors, namely technology (including computers), parent involvement, and peer tutoring, attempting to answer the question, "What is the best way of teaching the curriculum we have defined?" One of the first uses of computers in education was in the teaching of mathematics skills to primary level children. Fortunately, studies of at least one critical competitor, peer tutoring, indicate peer tutoring to be superior to the use of computers in increasing the mathematics skills of young children (Levin, Glass, & Meister, 1987). When relative costs are also considered, the differences are even more impressive in favour of peer tutoring. Those who have achieved highly in mathematics and other areas often mention their parents' support and valuing of the activity as important in their achievement. The factor of parental support has a long-term potency more than equal to that of computer novelty.

Consideration of creative writing leads to similar observations. Students write *more* with word processing, but further investigation usually reveals that students are spending more time writing. However, one finds that students may spend even more time with electronic mail. The difference between the two contexts is a well-defined audience, turning our thoughts to peers and parents. Peer tutoring is often a part of the writing program and parent approval is often given as a source of motivation.

Some computer programs claim to help individuals in achieving physical fitness, but peer involvement seems a more likely avenue. Those who have studied the school society carefully suggest that one of the reasons students tolerate the requirements of the school system is because it offers them a chance to socialize with their friends at the same time (Goodlad, 1984). If the most popular students participate in the desired fitness program, most others are likely to join. Similarly, parents who use automobiles to minimize their activity outside the home and other technology to minimize their activity inside the home create an environment hostile to physical fitness. Any instructional goal becomes more difficult to achieve if it runs counter to the underlying values of the surrounding culture.

Our consideration of these three examples ends here. The complete process includes comparison of the critical competitors, selection and implementation of those chosen, and repetition of the process on some regular basis (Ragsdale, 1985).

Not only is the effective use of computers in education dependent on systematic and logical analysis of needs, but this analysis is also crucial to successful implementation of a teacher development plan. Only if computers are used to meet demonstrable needs can we (or should we) expect teachers to acquire the associated skills.

Unfortunately, the computers-in-education literature often raises issues such as "how to maximize the potentials inherent in learning to use a computer" (Norton, 1985, p. 40). A preference for machine tutoring over human tutoring can be seen in Anderson, Boyle, and Reiser's (1985) evaluation of a LISP (an AI programming language) tutor program. Their first study found no differences in achievement, but did find that human-tutored students took slightly less time to complete the material than did computer-tutored students, while students working alone took a great deal more time (11.4 hours vs. 15.0 hours vs. 26.5 hours). The authors' second study, another comparison between computer tutoring and working alone (where computers were greatly superior) but omitting the human-tutored group (where computers were slightly inferior), shows their preference.

Though the preference is less marked, Bereiter's (1985) suggestion that student writers be given "random access to strategic moves" to improve their writing skills is similarly paradoxical. It is intriguing to compare this suggestion with Case and Bereiter's (1984) systematic developmental approach to instructional design. The latter hinges entirely on student need while the former is, by definition, independent of student need. Is the "ability of computers to provide random access" the need that is being satisfied?

Pea (1985) considers the uses of computers to assist the intellectual skills of students, but begins with an analysis of computer strengths, then builds these into a pattern of students and computers working together. As intelligent teachers see that they are being asked to assist in the implementation of an innovation that places machine needs (what do computers do best?) ahead of human needs, how can we expect them to respond?

Loucks-Horsley, French, Rubin, and Starr (1985) wrote about implementing technological innovations with teacher incentives and rewards. They identify the elimination of system disincentives, such as competing school goals or lack of equipment, as an important goal. Presumably one important disincentive would be the perception that technology applications were based on machine needs, not those of students and teachers.

The preceding suggests an alternative explanation to Perkins' (1985) analysis of implementing computers in educational settings. He believes the

assumption "opportunities get taken" is questionable, because the potential "takers" do not recognize them or are not sufficiently motivated. Perhaps teachers decline to participate because they recognize the assumptions on which the "opportunities" are based.

These analyses, based on "disincentives" and "opportunities," bring to mind Bob Davis's phrase from the 1983 AERA meetings, "Nullification through partial assimilation." He meant this as a method whereby teachers and schools can avoid the effects of innovation by adopting the most trivial aspects of the new technology. An example is the adoption of "open plan" architecture without the more important organizational or pedagogical changes. Consequently, when computer implementation is forced, teachers may look for the most non-threatening and innocuous applications, rather than uses with important impacts on teaching and learning. However, an innovation process based on a strong (human) needs assessment foundation may lead to implementation that teachers consider beneficial.

SUMMARY

Before closing, we should consider how this analysis might serve to deal with the factors listed at the beginning of this article, under "The developing problem." First, a definition of computer literacy has emerged, namely that students should be required to acquire computer skills that will assist them to master the rest of the curriculum.

Second, the problem of teacher motivation can be honestly dealt with only when the development process leads to skills that the teachers themselves have found important. The emphasis is on teachers making decisions in their own discipline areas, including input from teachers who do not use computers. Though some teachers will still be influenced by their informal experiences with computers, the participation of other teachers should provide a stabilizing effect.

Third, the needs assessment framework should help clarify the multiple roles of computers in education by tying applications more directly to curriculum demands. A discipline oriented analysis allows a more specific definition of development requirements than an approach that focuses on the technology.

Finally, and most important, this framework incorporates a value component, not only from the general population, through the process of determining educational goals, but also the values of teachers. It is unreasonable to expect teachers to increase their workload in order to incorporate computers into their teaching, without making sure that the computer applications are in congruence with their values. Jacques Ellul (1981) has described the problem well, in explaining a contradiction of technological

advancement, namely that as technology increases we are required to be more disciplined in our behaviour (e.g., following increasingly complex procedures in driving). But at the same time Ellul asserts that the need for discipline is further and further removed from underlying values (e.g., stop signs to 'discourage' traffic), as society in general loses its values (materialism, family breakup, more abortions than live births). The result is a tendency to challenge and/or reject all discipline, while at the same time increased use of technology is making the demands of discipline more severe. If the use of computers in education places demands upon the teacher that are interpreted (correctly, in my view) as a tightening of discipline, the need for a value foundation should be evident.

This paper is necessarily incomplete, for it only discusses a process for planning teacher development, not a definition of the skills required. However, although the skills may not be defined, the underlying values *must* be defined. Until we realize this our experiments in teacher development will result in confusion and alienation among teachers and students.

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