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The potential benefits of microcomputer use in the schools are gains in efficiency, equity, and quality of the instructional programs.

Instructional Policy and the Development of Instructional Computing: Maintaining Adaptive Educational Programs

by Dr. Robert L. Blomeyer, Jr.

In the last five years, the instructional use of computers in American secondary and elementary schools has demonstrated remarkable growth. Thanks to survey work on the "Instructional Uses of School Computers" directed by Dr. Henry Jay Becker at Johns Hopkins University, the 1983-84 National Assessment of Educational Progress, and others, we now have a growing body of information concerning the penetration of microcomputers in American schools and the variety of strategies that are being used to incorporate applications of microcomputers into schooling.

In data collected between spring 1983 and spring 1985, the Becker survey indicates that the number of computers in use in schools quadrupled from about 250,000 to more than 1 million. The survey used a stratified probability sample of 2,361 public and non-public schools and had a 92 percent response rate overall. Raw results were "reweighed" so that the reported results may be interpreted as being from a representative sample of all the schools in the U.S. (Becker, 1986).

The survey also shows that the instructional use of these computers differs sharply between the elementary and secondary schools. In elementary schools, over 50 percent of student use involves using "drill and practice" or "tutorial" software and only about 12 percent of the time is

spent writing computer programs. These percentages are nearly reversed in secondary schools, where computers are used for programming over 50 percent of the time and Computer Assisted Instruction (CAI) only accounts for about 16 percent of computer use overall. This means about 35 percent of the total computer use is due to a variety of other instructional applications in both cases.

This new evidence presents a profile of computer use in the schools and illustrates broad patterns regarding hardware distribution and the existing range of computer activities in the curriculum. However, many questions remain unanswered regarding conditions in the schools that may influence the development of instructional computing programs and shape the impact of computer use on learning. Salomon and Gardner (1986) discuss the issue of the "effectiveness" of instructional computer use. They compare research on school computer use to prior research on the instructional uses of television. In the research on instructional television, many investigators pursued questions about the "effectiveness" of TV as a delivery medium, in comparison with other alternatives. Salomon and Gardner discuss the idea that comparative methodological research pursuing questions about the relative "effectiveness" may be unproductive.

They conclude that the overall lack of significant findings from this earlier research may not be because TV is in itself ineffective as a medium. Instead they suggest that the insignificant findings may be due to the lack of sensitivity of "experimental" studies to other changes in the schools and classrooms where TV was being used. Their central point is that research, on new technology in the schools, pursuing questions on relative "effectiveness" (measured by comparisons of gains through testing) may be asking the wrong or an inappropriate question. They recommend that for organizing research on instructional computer use, investigators should learn from the shortcomings of the existing studies on instructional television. For new research concerned with understanding the outcomes of instructional computer use in the schools, more productive findings may be possible by organizing and conducting heuristic research that describes the context of computer use and provides information useful for discovering specific questions that can be tested as hypotheses in subsequent research (Salomon and Gardner, 1986).

A few descriptive of "ethnographically oriented" studies from the 1970s provided valuable precedents for conducting contextually relevant research on instructional computing programs. This early research provided the basis for a stable core of "foreshadowed issues" that have great relevance for understanding our present situation. An issue raised by Smith and Pohland (1974) concerned the effects of a community's dominant cultural pattern on the implementation of instructional computer use in the schools. They found that the use of CAI in schools was not as simple as assigning the students time on computers to complete instructional tasks. Instead, CAI was found to be a complex mixture of "... physical, social, emotional and cognitive behaviors inextricably intertwined and shaped by both administrative routines and norms of the particular schools and classrooms" (Smith and Pohland, 1974, p. 36).

Other pioneering research on instructional computing (Stake, 1977) pointed out that there are particular attributes associated with the role of the teacher in classrooms where computers are present that have significant impact on whether students succeed or fail in adapting to the use of the new instructional medium. In a study of PLATO and fourth grade mathematics, students with a limited reper-

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toire of learning strategies encountered severe difficulty and tended to give up without the intervention of the teacher. In the reported findings it appears that the participating teachers had become well versed in the routines necessary for the effective use of computers in the classroom probably through immediate contact with the developers and designers involved in the PLATO implementation project. This suggests that productive attitudes and management protocols are best learned through direct contact with educational professionals who are by now experienced with integrating computers into the school setting. These findings are significant for teacher "computer literacy" and for teacher training.

Case studies and other descriptive research in the '80s usually focus on staff training, hardware and software distribution, school conditions affecting access to computers, software design issues, and a broader concern for an appropriate integration of instructional computing with prior curriculum content and objectives. Two studies of particular interest for their portrayal of school computer programs are Sheingold, Kane, and Endreweit's comparative study (1983) of instructional computing programs in three contrasting school districts and Meister's single case study (1984) of a "model" elementary school microcomputer program in the San Francisco area (also see Blomeyer, 1985, and Cline, Bennett, Kershaw, Schneiderman, Stecher, and Wilson, 1986). A similar constellation of issues is discussed in the ethnographically-oriented literature on instructional computing in both the 70s and the 80s. Enough information is provided in these studies that we can begin systematic discussion and analysis of policy at the federal, state, district, and local school levels. This analysis of instructional computing policy, and the examination of its relationship to teaching practice, can assist in the timely and appropriate integration of microcomputers in all areas of the elementary, secondary, and post-secondary curricula.

For example, the IBM/ETS Secondary School Computer Education Project suggests that a major component of instructional applications in secondary schools is the classroom use of applications software (word processors, database programs, and spreadsheets; Cline, et. al., 1986). Lockheed and Mandinach (1986) go on to suggest that while the comprehensive integration of computer tools into the full range of the subject areas is a worthy objective, current difficulties concerning logistics, available materials, and teacher training make the comprehensive approach difficult at present.

As an alternative, Lockheed and Mandinach describe an integration strategy that optimizes the "fit" or curricular appropriateness of generally available software tools. They suggest developing an "applications-based course" for students that would teach the use of generic software tools (like word processing, etc.). When students learn to control generic tools, subject matter courses can then draw on these abilities and allow development of linkages to the remainder of the curriculum. Meanwhile, the other problems blocking comprehensive integration of computers and curriculum (i.e. insufficient access to hardware, inappropriate software, and low levels of teacher training on technology) can be improved. They argue that adopting this approach on an interim basis will improve the equity of instructional computer use and ease the development and implementation of new programs while offering immediate benefits that will contribute to improving educational quality.

In a multiple site case study of microcomputer use in secondary school foreign language teaching, Blomeyer (1985) found the level of functional computer literacy for

both teachers and students was a major factor in the quality of the three programs that were studied. State, district, and local school policies influenced these "literacy levels." It appeared that a school district policy explicitly requiring each student to take a "computer literacy" course (or demonstrate equivalent competencies) had a positive influence on the equity of school computer use by enabling female and minority students to use microcomputers in other classes. It also appeared that curriculum-wide use of microcomputers as an instructional resource provided greater equity within a school than use limited to mathematics and vocational technology.

Teachers in all subject areas were given a systematic inservice introduction to the computer literacy curriculum before the class was first offered to the students. These initial levels of literacy were sufficient to sustain the teachers during the first two years of the program. However, the foreign language teachers who were developing CAI lessons found out that as student literacy in the school population increased, it was necessary for them to increase their technical sophistication as courseware developers. As the students became more sophisticated in computer programming skills, they often used their new skills to modify CAI programs instead of helping them study their Spanish or German. It seemed that increasing student computer literacy required an overall increase in staff technical abilities to reduce the probability of management and behavior problems affecting the use of microcomputer laboratories.

Another policy issue discussed in Blomeyer (1985) concerns district or school support of local software development. Observational data and interviews indicated that the successful integration of microcomputers as a supplemental delivery medium in foreign language teaching was substantially enhanced by teacher produced materials. These materials had close "fit" to the curriculum and saved class time that the teachers would ordinarily have spent in vocabulary and grammar drill and practice activities. This classroom time was apparently reallocated to other more complex in-class activities aimed at increasing student "oral proficiency" in the languages studied.

Not all the outcomes of teacher participation in software development activities were positive. In general, participation in lesson design and development was an extremely labor intensive activity that sometimes conflicted with the teachers' more traditional roles as foreign language teachers. Increased workloads, stress, and potential for "teacher burnout" were observed among teachers who participated in courseware development projects. One teacher studied voluntarily reduced her teaching appointment so she could continue to develop and publish lesson materials. Overall, it appeared unlikely that the teachers observed would be able to sustain the level of effort necessary to continue materials development efforts without significant changes in the level of incentives offered to support these activities. Summer salaries, support from highly proficient programmers and "computer aids" hired to assist with computer laboratories provided some relief from the added workload (Blomeyer, 1985). Another solution indicated is temporary reduction of teaching load for individuals participating in the initial development or pilot use of computer-based instructional materials.

The conclusions summarized above on the "human costs" of local software development activities are paralleled by a frequently quoted cost effectiveness analysis of computer assisted instruction (Levin, 1984). This analysis indicates that there is a predictable "resource/energy trade-off" related to the direct costs of hardware and the indirect

or "hidden" costs associated with personnel in a school where CAI is used as a regular part of instruction. According to Levin's calculations, for every dollar in direct costs that is spent on hardware, an expenditure of three dollars can be anticipated for other indirect costs; including software, fixtures, maintenance, and especially expenditures for training or hiring new staff to assist with the operations of the computers in education program (pp. 16-20). If the existing faculty and staff must absorb the majority of the "hidden costs" associated with implementing microcomputer programs in the schools, then low teacher morale and high teacher turnover may have a potentially negative effect on the educational program. In short, no programmatic, structural, or technological innovation is entirely without risks. These must be carefully weighed against possible benefits and decisions should be made according to the greatest potential for constructive change.

On the more positive side, my finding that classroom time can be reallocated from repetitive drill-related activities to tasks of a more challenging nature is paralleled by a body of earlier research on the use of "drill and practice" programs and has been called "the CAI phenomenon" (Bright, 1983). A frequent assertion regarding the instructional use of computers as an integrated component of schooling is that the use of computer-based instruction (CBI) or computer-assisted instruction (CAI) results in equivalent learning outcomes which take less time than more traditional methods.

Although the majority of studies reporting this time-compression effect were conducted on the use of programs designed to teach math facts (Jamison, Suppes, and Wells, 1974; Kulik, Kulik, and Cohen, 1980; and Bracey, 1982) my research on computer-based language learning presents a slightly different interpretation of related findings. Foreign language teachers reported that the use of computer-based drill and practice of vocabulary and grammar exercises allowed the teachers to spend more classroom time on increasing the students' "oral proficiency" or ability to use the foreign language for spoken communication (Blomeyer, 1984 and 1985). While the same amount of time was used for teaching each content objective, students had the opportunity to practice their language skills in more diverse contexts.

Two relevant conceptions of educational improvement are the "functionalist" perspective and the "inquiry" perspective (Greenstone and Peterson, 1983). The functionalist view of educational improvement assumes that schools and school administrators have an obligation to provide services and social functions that are mandated by the larger community. Improvement of education is accomplished by changing the allocation of resources to reshape student and teacher behavior. In contrast the inquiry perspective stresses that educational improvement is an outcome of changes in teacher motivation, insight, and flexibility which are supported by school administrators and the local community.

The individual classroom teacher is the lead element in the inquiry approach to educational improvement. Teachers serve as models who transmit intellectual skills and broad cultural traditions. The inquiry orientation stresses the development of every person's intelligence in accord with accepted standards for competence and excellence. In these terms, good teaching is being adaptive to students' individual areas of academic and interpersonal strength and weakness. According to Greenstone and Peterson, the inquiry perspective emphasizes the teacher's need for freedom and autonomy within the classroom.

If the "inquiry perspective" on policy concerning educational improvement is accepted, then the additional flexibility that is a possible outcome from the instructional use of computers may provide a significant positive influence on teaching and learning. Rather than viewing computer technology as a system of technical artifacts and skills that have intrinsic value in pursuing high status technical employment, computer use in the schools can be seen as a valuable delivery system that can potentially become and integrated part of the traditional American school curriculum.

Another result of adopting the viewpoint of the "inquiry perspective" is to regard instructional computer use in the schools as a powerful force for maintaining and supporting the centrality of the traditional subject matter curriculum. Individual needs and differences within the student population can be addressed effectively by using the flexibility that is possible through the integration of microcomputer-based instruction as a component of educational programs which adapt instructional levels and methods to meet the needs of each individual student.

Planning for school computing programs that can provide increased instructional flexibility requires a comprehensive approach. Just as Stake (1977) found that significant aspects of the computer-using teacher's role need to be learned through contact with more experienced peers, administrators can also gain insights from their colleagues who have experience developing comprehensive computers in education programs. A model for program planning suggested by one such plan is proposed by Vakos (1986). He presents a planning and development model with four stages: (a) initial discussions, (b) development and adoption of a formal district implementation plan, (c) implementation, and (d) program evaluation. Ten steps are considered to be critical for the success or failure of the program development efforts:

1. local needs assessment,
2. a clear statement of a program philosophy,
3. establishment of school board policies addressing local needs and program philosophy,
4. development of administrative procedures,
5. specification of learner goals,
6. establishment of learner priorities,
7. specification of equipment needs,
8. preparation of bid specifications,
9. integration of microcomputer use into the comprehensive subject matter curriculum, and
10. design of an appropriate program evaluation measuring the success or failure of the program in meeting its programmatic and instructional objectives.

(Vakos, 1986, pp. 56-58).

An important feature of Vakos' approach to program planning and development is the degree to which policy issues dominate the ten steps summarized above. While the article apparently describes the personal experiences of the author, many of its conclusions are paralleled by the general recommendations of Cline, et. al. in the summary chapter of their volume on the IBM/ETS project. Their principal recommendations are:

1. Develop a written plan for integrating the computer into the learning process,
2. Make a multiple-year commitment to establishing a comprehensive program,

3. Use a shared planning approach to ensure a broad base of participation and support,
4. Teach all students to use microcomputers as tools to facilitate learning in many subject matter areas and extracurricular activities,
5. Ensure that computing programs do not reinforce economic, racial, or gender disparities,
6. Recognize that using computers in the instructional process will create additional work for teachers.

(Cline, et. al., 1986, pp. 133-134).

These recommendations summarize the findings of the IBM/ETS project, but they also have been echoed in many of the other contextually grounded studies of instructional computing programs discussed here.

The potential benefits of microcomputer use in the schools are gains in the efficiency, equity, and quality of the instructional programs in our schools where there is no "zero sum choice" in which any one initiative might negate gains in the other two areas. To realize maximum gains, administrative decisions on the selection, distribution, and disposition of instructional computing resource should support increased flexibility at the classroom level. Teachers must have the training, resources, and adaptability to integrate the use of computers as instructional resources which support the central elements of the comprehensive curriculum. By providing teachers with adequate technological resources and instructional flexibility, American education can use computers to increase the adaptability of classroom instruction to individual students' needs and to improve the effectiveness of schooling.

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