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ABSTRACT

Fifth in a series of six monographs on the use of new technologies in the instruction of learning disabled students, the paper describes how schools can plan for the acquisition of computer hardware and software, and how they can provide district-level staff training in its use. Discussion focuses on the development of a technology implementation plan and on a critical analysis of the three major components of a school-based computer approach: hardware, software, and training. Topics addressed include current approaches to technology implementation, components of the planning process (Board of Education, district planning committee, and key persons at the local level), and key issues and decisions (e.g., centralized or decentralized decision-making, short- or long-term plans). Issues related to training and staff development are also discussed; these include encouraging teacher participation, content of inservice programs, and designing effective training. Aspects of hardware selection (stand-alone and network systems) are addressed next. The monograph concludes with a discussion of issues associated with software selection (acquisition of courseware libraries, delivery systems, and local courseware production). (JW)

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Optimal Approaches to Microcomputer Implementation in the Schools

Thomas Bakke

AMERICAN INSTITUTES FOR RESEARCH IN THE BEHAVIORAL SCIENCES
P.O. Box 1113, 1791 Arastradero Rd., Palo Alto, Ca. 94302 • 415/493-3550

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Introduction

Increasing availability and sophistication of new technology, combined with decreasing costs, has led to its widespread adoption in elementary and secondary schools. Judging from industry sales projections, we have seen only the tip of the iceberg. Over the next few years, the acquisition of technology by schools will continue at accelerating rates. Yet with increases in such expenditures, there is growing concern that purchasers may not be making the best choices about what to buy, and how to use what they have purchased. The need for well-informed planning and decision making is great. Decisions now being made will likely have important long-term consequences.

The purpose of this paper is to discuss how schools can plan for the acquisition of computer hardware and software, and how they can provide district-level staff training in its use. Our discussion has two foci: (1) the development of a technology implementation plan, and (2) a critical analysis of the three major components of a school-based computer approach: hardware, software, and training.

We have limited the scope of this paper to instructional applications of technology in the schools. Other applications, particularly administrative and vocational uses, while important, are broad subjects that merit separate treatment.

Current Approaches to Implementation

Schools are acquiring and using new technology in a variety of ways, each the result of a particular set of unique local circumstances. Yet it is often the case that purchases and choices regarding use are made without adequate planning, and that poor planning causes subsequent implementation problems (Steber, 1983, Sheingold, et al, 1981).

It is useful to begin with a general description of the most common approaches to the technology implementation process. Three broad categories can be defined along the dimension of "extent of planning."

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The non-planning approach

The basic feature of this approach is lack of any specific or coherent plan of action before equipment is purchased or otherwise acquired. Decisions are made by default at the local level. These schools "let events in which they do not actively participate determine how students and teachers acquire computers and computer competencies" (Rampy, White, and Rockman, 1983). Schools lacking a role in a formal decision-making process at a higher level (district, regional, or state) may simply purchase equipment out of their own funds as a first step in getting started. Sometimes the equipment may be donated by individuals or companies. In any case, a minimal school-based plan does eventually arise out of necessity. However, the plan usually has a loose fit with the needs of the school, resulting in a far less than optimal allocation of resources.

The adhoc approach

A more common mode of implementation is the development of an informal plan to meet limited or short-term goals. This type of planning usually occurs through the initiative of key school staff. Fisher (1983, p. 52) has noted that a particular teacher at the school is often "instrumental in the acquisition of microcomputers at that school and [has] a plan, usually unwritten, for their use"(p. 52). In many cases the computers are used as a supplement to instruction or for teaching programming. As the number of computers within an adhoc-approach school increases, there is also an increased need for a set of longer term goals and for a more formal and coherent plan. Yet when steps are taken to meet such emerging planning needs, computer resources that are already in place (as the result of adhoc approaches) often influence the new plan. Planners feel committed to adding resources in ways that complement those that exist. This may, at times, constrain the development of a truly optimal program.

Formal planning approaches

Formally planned computer implementation involves the development of an explicit rationale for expenditures that identifies the organization's (a) computer needs and intended applications, (b) goals and expected outcomes, (c) criteria for evaluation and selection of hardware and software, and (d) personnel and training requirements. Formal implementation plans have evolved slowly since the time that computers were first available for school use, and many of the formalized approaches are modeled after approaches to implementing large scale mainframe systems. As the amount of computer technology in the schools has increased, the application of formalized approaches has become more important, necessary, and common. One important dimension along which planning approaches vary is the institutional locus of authority and control. Authority for different aspects of planning may be vested within state agencies, districts or regions, and schools.

State leadership has been a significant force in developing comprehensive computer use plans and in providing assistance for the implementation of computers at local and district levels (Bingham and Manock, 1982). State-wide approaches are often developed with two goals in mind: (1) gathering information from the schools and districts rapidly, efficiently, and in a standardized manner and (2) providing some form of guidance to the schools and districts that will maximize the likelihood that resources and information will be shared among schools. Typically, the state provides a general policy framework within which subordinate organizations as expected to design more detailed programs to fit local needs.

Districts, however, appear to have been most successful than states in developing and managing the implementation of formal planning processes. It is not hard to understand why this is so. Districts are clearly better attuned to the particular needs and interests of its schools and students than a state department of education can be. The logistics of communication and funding often favor a district-planned, school-implemented approach.

As the site of service delivery, the school should be involved in producing formal plans. Schools are inevitably charged with the final responsibility for the success or failure of the program. To date, formal planning at the school level typically has been an outgrowth of non-planning or adhoc planning. While planning at the school level will continue to be very important, indications are that increased interaction with the district in joint planning efforts holds the most promise for the development of approaches that meet local needs well.

Components of the Planning Process

Very little has been written on the actual process of district-wide planning for the implementation of microcomputers in the schools. The limited information available indicates that certain components of the process have been most important for efficiently identifying and meeting school and district computer needs.

Key actors

Three major "actor-groups" can be identified which are usually involved in successful district planning processes: the Board of Education, a planning committee (or possibly a task force or an advisory committee), and key persons at the individual schools.

The Board of Education. A critical element in the planning process is to gain the support of the local Board of Education. The Board's support is necessary as a source of direction as well as funding. The desirability of early involvement of the Board is too often overlooked in planning models.

The Board's most important role for initial planning is often to help in formulating a statement of philosophy for the computer use program (Filliman, 1983). This philosophy can serve to clarify the goals and tasks of the committee charged with developing a comprehensive plan for computer use (Bjorum, 1982).

Implicit in gaining support of the Board is the importance of establishing a formal system and network of communication (Trainor, 1983). Many of those involved in planning are new to district planning processes because they have positions within the school structure that do not normally involve them in policy matters. Establishing effective communication channels is a critical early step. Since much of the planning for computer use is a "bottom-up" process, with ideas originating at the classroom teacher level, (as opposed to the "top-down" process that characterizes much educational decision making) it is inevitable that new communication roles and channels will be established or will evolve. Through its policies, the Board can facilitate the development of improved communication.

<u>The district planning committee</u>. The establishment of a planning committee charged with the responsibility of formulating the overall plan for implementing computer use, is another important early step. This committee is perhaps the most critical element in the planning process. Its success depends upon several factors: its composition, its approach to information gathering, and its priority setting and decision-making style.

The first and most important decision in formulating a planning committee is to determine its composition. In many cases, the committees are formed voluntarily and independently by knowledgeable and interested key persons (BOCES, 1981; Filliman, 1983). In other cases, the Board appoints individuals to an advisory committee to assist in the planning process. It is not hard to identify key persons within the school system. Usually they have been instrumental in other computer related planning or organizing activities. If computers have not yet been introduced, appropriate key persons can often be identified by their leadership roles in other curriculum or staff development initiatives. Through their personal networks these persons can identify teachers and administrators with valuable information or leadership capacity. This approach is commonly used to ensure that a comprehensive and representative committee is formed. In order to ensure a broad base of support, it is often quite useful to include knowledgeable parents, local business persons, and other community members. In the long run, these outside members can have important consequences for the success of the program by disseminating information and generating financial and in-kind assistance.

The planning committee usually conducts a needs assessment based upon the newly established computer-use philosophy. The needs assessment will help answer questions concerning what goals and objectives should be included in the implementation plan. It will also assist in establishing priorities, such as what should be emphasized in the computer program (e.g., computer literacy, supplementary or direct instruction, or programming), and how resources should be allocated (e.g., which schools and in what sequence). The needs assessment should determine the long-term needs of both the students and teachers to provide a foundation for a multi-year plan. Initial implementation, however, should be based on immediate and pressing short-term needs. The long-term plan will nearly always require revision after first implementation efforts turn up areas in which the plan can be improved. A flexible attitude regarding revisions to the multi-year plan, based upon periodic reassessment of needs, should be maintained.

An integral part of the needs assessment and planning process is information gathering. There are numerous sources of information that may be helpful. Visiting other school districts with computer programs and talking with teachers is one of the most cost effective and practical ways of finding out what is current and practical. Visiting hardware and software dealers is another. Many educational computer magazines and databases contain reviews of hardware and software, as well as descriptions of the experiences of other educators and schools with similar needs. The amount and variety of information can indeed be overwhelming. It is important, therefore, that information needs and sources be clearly identified and that evaluation is carried out systematically. Regular meetings should be held to assess progress in planning and to disseminate information gathered to key persons in the decision making process. The frequency of these meetings should be a function of the time available for planning, the scope of the plan, and the progress being made. Some districts have spent six to eight months in the planning stage and have found monthly meetings to be satisfactory.

<u>Key persons at the local level</u>. This group is generally composed of the principal and lead teachers who will be using the computer equipment. It should be the principal's responsibility to recognize and organize key persons, as well as to encourage other interested persons to join the group. The importance of this group cannot be over-emphasized. They are best acquainted with the needs of their school and ultimately will have the most impact on the integration of the new resources into their instructional activities and the activities of others. Key persons at local schools should specify what it is they need or want, why they need it, who will use it, and where the full funding can come from. Their continuing input to the planning committee is fundamental to sound planning.

Elements of successful planning

The following points briefly summarize the elements of successful planning for microcomputer implementation.

- It is important that the goals of the program be articulated, agreed upon, and supported. These goals will provide a framework for the planning committee to work within while developing the specifics of the program (Bjorum, 1982).

- Local school personnel are most familiar with their needs and wants and are therefore the most likely starting point for deciding what should be considered. A Rand Corporation study of implementation processes of 293 local innovations over a four-year period found that "effective strategies were the ones adapted to the reality of the local setting" (Grossnickle and Laird, 1983 p. 106).

- The best designs are those that can be adjusted to changing situations. In fact, even "the best-planned implementation models will require alterations and additions each step of the way. The key to success is flexibility" (Filliman, 1983 p. 56; BOCES, 1981).

- Regular meetings and formal structures and channels of communication are essential to good planning (Grossnickle and Laird, 1983). There is no substitute for good communication. It reinforces the group commitment and keeps the group focused on its purpose. Good communication flows both up and down the hierarchy of decision making, instilling a sense of "ownership" in the members.

- There must be a high degree of commitment between the members, particularly among the Board. Futhermore, commitment, like communication, must be maintained even after the program is implemented. It is especially important that key members remain committed and provide leadership and leadership training.

- "The plan is political, and politics will play a large role in its ultimate acceptance or rejection. Such a district plan cannot be carried out by fiat or by the small committee which initially creates it" (Fisher, 1983 p. 52). Cooperation and support are required at all levels in the district to ensure success.

Key Issues and Decisions

Centralized or decentralized decision-making

The extent to which decision-making should be centralized is an issue which many schools find difficult to resolve. In addressing the issue, the size of a district and the resources available (personnel, materials, finances) are important considerations. Although organizational theory suggests that centralization of decision making is likely to occur with increases in size, our own observations, (based on a limited local sample) run counter to this principal. Complexity of the decision-making process often increases with the size of the district. It is a difficult task to make decisions for 20 or more schools, in particular if the schools serve student populations with different needs. Substantial resources can be spent at the district level, trying to choose among the variety of possible choices in a way that will be seen as equitable by school-level staff and parents. Under such circumstances, the district may be better off playing a consulting role to the individual schools. On the other hand, it may be more efficient to centralize information collection and decision making when there are only a few schools in the district. One or two people at the district office may be able to provide leadership and coordination, working closely with staff in a small number of schools. The approach best suited to the unique characteristics of the district, in some cases, can best be determined by trial and evaluation.

Short or long term plans

Both near-term and long-term planning are advised. Long-term plans provide perspective. Short-term plans are of greater practical importance. A long-term perspective should be flexible, however. Goals that are currently being set for high school students may be radically different in five years, due to younger students' increasing access to computers. The continual drop in prices for hardware, the rapid changes in technology, the availability of quality software, and changing school staffing requirements may all cause significant shifts in goals and plans. Equally important will be the future financial condition of schools. Many computer programs were initially started with non-standard sources of funding. As those funds are generally from one-time sources, a critical question is how the funding and budgeting of new technologies will change as computer-based instruction becomes more institutionalized, and how these changes will affect the shape and direction of the computer program.

Evaluation and accountability

In many schools, this has been a neglected aspect of computer implementation programs for a number of reasons. First, most programs are still in an early stage of development, and summative evaluation approaches may not be appropriate. Other programs are growing so rapidly that there is little time for evaluation. However, maintenance of quality programs will require regular feedback and evaluation, both formally and informally. In the early stages of development, formative evaluation is likely to pay off in directing attention toward needed refinements to initial implementations. As computer-based programs become more of a standard part of school educational approaches, one should expect to see a shift toward summative and accountability oriented evaluations.

Organization of resources

The question of centralization or decentralization of resources is at the heart of the organization issue. However, districts do not ordinarily choose one approach or the other. Rather, a continuum exists between these two polar influences, and districts choose a mixed approach aiming to best meet their needs.

We will consider the question of organization of resources in two parts. First, we examine resource organization within the district, focusing on the provision of training (a personnel resource) and courseware. Second, we discuss resource utilization within the school, primarily as it pertains to computer hardware.

District-based contributions to implementation of computer-based education have primarily involved staff training. This has resulted from the diversification in computer applications, limitations in the number of teaching staff with computer knowledge and skills, and inadequate existing local (community) organizations for computer training. The need for a centralized district-level training service will remain because individual schools are less able to provide all the specialized computer knowledge that is likely to be needed by staff. However, more and more often the location of training that is district-managed is at the local level.

Courseware is another area where it seems logical for the district or the county to provide centralized services. Districts have attempted to follow this policy where possible, but a trend toward decentralization seems to be taking place because of unique district funding and logistical problems.

The optimal organization of computer hardware within the school is a researchable subject that warrants in-depth study. The actual management of local resources generally fits one of three models. One model is to locate individual computers in particular classrooms for use with specific courses or groups of students. A second model is to make mobile computers available to teachers on a short term basis as the need arises. The third approach is to locate computers in labs or mini-labs, depending upon the number of computers the school owns. Based on the literature and observations AIR has made in the San Francisco Bay area, the last two models appear to be the most popular and lead to wider applications. The particular model to be used is often chosen by the planning committee and is determined by the availability of hardware and software and by priorities for their use. Hence, most organizational models amount to practical adaptations to local situations. An important and as yet unanswered question is the relationship between these types of organization and the extent of use made of the equipment and courseware.

Each of the three models implies a different set of situations that may have both positive and negative consequences for students and staff. One problem that may arise is scheduling. How well do different models accommodate a variety of uses? How can staff be used efficiently to meet these demands? This is a complex problem but the answer may, in part, be found within the computer use plan. The objectives of many plans, especially for elementary schools, are to teach computer literacy and awareness. Programming and other elective uses have been concentrated at the junior and senior high schools. As the general computer literacy of the student population increases, the demand for extended variety and quantity of use will increase rapidly. Already the spread of computer technology has penetrated the home environment. In addition, parental influence is likely to encourage higher student use. The model that is elected should be comprehensive enough to enable the schools to meet these scheduling challenges.

One of the questions addressed by computer use plans is whether students can work together at the same computer. By answering this question the schools will be able to plan for the optimum number of computers. Although the consensus is that they can, educators vary on the best ratio of students to computers. For exploratory learning environments, such as LOGO, from one to four students per computer can work effectively. For computer assisted instruction, the optimal number of students may be closer to two per machine, depending upon the application. More complex programming is probably better suited to individual use. While sharing is a common computer practice, peer tutoring has demonstrated the utility and practicality of multiple student use of computers (Targ, 1981). Further research on tutoring and sharing needs to be carried out to study their effects on learning and interaction during computer use.

Another area of resource organization that warrants study involves human factors considerations. Yeaman (1983) reports that although "some effort has been made to determine room arrangements for instructional computing purposes, the need to fit microcomputers to students using them appears to have gone unrecognized" (p. 16). In 1981, the National Institute of Occupational Safety and Health (NIOSH) issued a report that made recommendations for improving specific physical situations involving computer use, but suggested that further study was required. Research into what physical arrangements produce the greatest motivation and learning for the student, if any, would certainly be beneficial.

These issues suggest the importance of considering the needs of special student populations when implementing and organizing computer resources. A recent study of 12 school districts using microcomputers in their programs (Hanley, 1983) found that initial planning and adoption of microcomputers often occurred without the heavy involvement of district-level staff. Nevertheless, this did not preclude subsequent successful sharing of computer resources.

> "In fact, some of the most successful uses -- in terms of the numbers of teachers and students involved and the diversity and extent of applications made -- occurred in districts where the microcomputers were available to both special and regular education [illegible]s" (p. 4).

When one or more computers are in a fixed location other than a main lab, it can be described as a mini-lab. It seems to offer a viable solution to some of the scheduling problems. In one secondary school district AIR has studied, mini-labs have been established at all five high schools. Mini-labs have been used for business, vocational education, mathematics, special education, career center, economics, and computer clubs.

Use of computers during free periods is another means of managing excess demand by students. This type of application varies in terms of its design and degree of implementation. Some schools provide computer use before school, during lunch time, immediately after school, and even occasionally on weekends and evenings.

Training and Staff Development

As discussed above, the specifics of what is taught about computer use, how it is taught, to whom, why, and when, varies from district to district and even among schools within a district. Rather than attempt to present an exhaustive review of each of these issues, it is helpful to look at some of the critical elements in the process of developing effective inservice training. What are the problems and how can they be solved? What positive results can be identified? What makes inservice training "good," and why?

A staff development program serves two basic purposes: (1) to allay teachers' fears and change their attitudes about computer technology, and (2) to encourage and assist staff in acquiring knowledge and skills for integrating computer technology effectively into the curriculum.

There is widespread agreement that staff inservice training represents the most important part of the computer implementation plan (Petruso, 1981; CUSD, 1981; Bjorum, 1982; Better and Miller, 1983). Training is important not only in the initial implementation phase but also for continued development of the program. A good inservice program is not static. Rather, it is a dynamic process that changes in response to changes in its environment--new equipment and software is acquired, curricula evolve, and district resources change over time. Ragsdale (1982) has suggested that inservice training is likely to become more important with time because of increased needs, more resources, more student demands, and different and greater pressure on teachers.

Altering staff attitudes toward the acceptance of computer technology is the initial step in the inservice program. Studies have indicated that one of the greatest obstacles to the implementation of computer technology is teacher acceptance (Rockart and Morton, 1975). In a study carried out by AIR, Russ-Eft and McLaughlin (1983) reported that resistance to this technology stems from fear of the unknown, increased demands on the staff, perceived changes in classroom, lack of time, and the belief that the computer may not be appropriate for particular applications. There is also the fear that such technology is associated with a progressive dehumanization (Holmes, 1982; Wilson, 1981). Overcoming these fears is therefore a major objective of successful inservice programs.

It has been suggested that schools offer a general introduction to the computer and its potential uses in the classroom (Boyd, 1981; Petruso, 1981;

Rose, 1982; and Townsend and Hale, 1981). In fact, this suggestion has been incorporated into many inservice programs through workshops, presentations, and demonstrations. Morrissey (1982), Rawitsch (1981), Nansen (1982) and Anadam and Kelly (1982) have made specific recommendations for these introductory training sessions. Some of the consistent recommendations include starting with simple concepts and advancing a little at a time, eliminating unnecessary jargon and technicalities, emphasizing successful experiences, avoiding programming at the start, stressing the importance of the teacher, and providing an overall perspective.

There is less agreement on what kinds of training are necessary or desirable beyond the introductory level discussed above. For example, some districts may structure their inservice toward the teaching of programming skills, while some are oriented toward the use of computer-assisted instruction, and still others may be interested primarily in teaching computer literacy and awareness. Clearly, all of these kinds of instruction constitute important aspects of a comprehensive training program. Of course, the kinds of training a district pursues should be based upon the needs and goals identified by their planning committee. In general, however, the district training package will consist of a general approach intended to guide schools and teachers. It is simply not possible for the district inservice program to identify and meet all the particular needs of its staff. Therefore, the inservice training programs at the individual school level should be designed to complement the district's programs while meeting each school's specific needs.

The district inservice program characteristically plays the lead role in this two-tiered training system. First, the district must decide what is needed, how, when, and where it should be offered. To be effective in this task, the district must provide an opportunity for school staff to indicate when and where training would be convenient. Second, the district must provide the opportunity for schools to design their own specific inservice. And third and most important, it must ensure that the training is compatible and the system works. The district must provide the incentives and opportunities that lead to optimal staff utilization.

An exemplary training program

In Cupertino Union School District, Cupertino, California, which has been identified through a national evaluation as having an exemplary program, the staff development approach has five basic program components (Better and Miller, 1983). The first component, designed to meet individual and school site needs, is a district-wide offering of courses that district personnel can take. These courses are taught by specially trained district personnel and are designed to meet the practical objectives of the individual teachers. The district offers a wide range of incentives to encourage teachers to seek this training on their own time.

A second component is staff development at the school site. It is accomplished through the interaction of a development coordinator, a principal and the school's teachers. The purpose is to "design course goals and objectives that directly relate to that staff's unique learning needs." To facilitate effectiveness of these programs, leadership training specifically designed for administrators is offered through the district.

A third component of the district model is the use of "computer resource teachers" (three half-time teachers in the district). The special experiences, knowledge, and skills of these teachers enable them to respond to requests from schools for needed additional training and services. This provides both the district and the school with dependable and rapid access to resources and information.

A fourth component of staff development is a lead teacher network. Members include a lead computer teacher from each school site, as well as others with specific computer responsibilities. Meetings are held once a month to discuss ways to assist staff in improving their school's computer program. A significant aspect of this component is that it provides for an exchange of information and ideas among teachers throughout the district, thus serving an important function in information sharing.

A fifth component, still in an emergent stage, is the implementation of a computer practice lab. The lab has grown out of the recognition that teachers want and need more hands-on computer time to apply what they are learning. In addition, the lab gives teachers a wide range of learning resources and opportunities with their peers in an environment in which assistance is available to them. Staff are permitted to sign out computers for overnight home use--an opportunity most frequently taken advantage of over holiday periods.

Gaining participation

In order to ensure that sufficient staff development occurs, it is quite often necessary to offer incentives to encourage teacher participation. A common incentive is that teachers can receive credit toward salary advancement, credit toward university, college, or conference fees, and in-kind "credit" exchangeable for materials and/or supplies. However, these incentives may still not be enough to reach staff development goals. Teachers may not have enough time or motivation to pursue inservice courses. They may feel that they don't need training, or that the training offered is not adequate for their needs. Our conversations with educators indicate that a great deal of training is acquired by self-motivated teachers, and that a sizable portion of this training is acquired outside the formal district system through the teachers' personal initiative.

A related situation in many school districts today is the importance of the auxilliary staff in the computer program. Volunteers and part-time personnel occupy a critical role in the operation of many computer programs. Although the involvement of the community is important and desirable, administrators sometimes attempt to have teachers assume auxiliary roles whenever possible. Nevertheless, most educators have indicated that their district computer programs could not function without this additional help. There are a number of reasons for this situation. One reason is the current lack of teaching personnel with computer knowledge and skills. Another is that there is limited and unstable funding to provide for employment of district-paid personnel. As a result, the schools have become dependent upon the local community for support. A good training program should therefore strive to include parents and other interested community members.

The content of inservice

The dispute about what should be included in an inservice program has been due to the various interpretations of the term "computer literacy." Anderson and Klassen (1981, p. 131) have defined computer literacy as "whatever understanding, skills, and attitudes one needs to function effectively within a given social role that directly or indirectly involves computers." In addition, the role of computer programming has been given varying importance within this definition. Ershov (1981) equates computer literacy with computer programming. Other authors (Poirot, Taylor, and Howell, 1981) have stressed different sets of competencies for teachers, not all of which require programming skills. As technology continues to evolve, Ragsdale (1982) feels that the requirement for programming skills by teachers may decrease since the procedures for controlling, creating, or modifying programs will be increasingly "built-in."

The approach of Poirot, Taylor, and Howell (1981) in designing inservice training provides insight into solving this problem. They have outlined three sets of competencies needed by teachers. The first refers to computing competencies needed by all teachers at all levels and disciplines. This includes the ability to read and write basic programs and to use courseware packages. It also includes knowledge of terminology, history, problems, and potentials of computer use. The second set, which presupposes the first, includes those competencies needed only by the teacher of classes about computing as a subject, such as detailed knowledge of computer programming and architecture. The third set includes competencies designed for teachers who intend to "use computing to support or enhance instruction in subjects other than computing." This description of competencies indicates a useful direction for districts to follow in deciding what to offer and to whom, while still providing flexibility for variations in local needs.

The importance of teachers being trained in computer programming skills has been overstated. Very few teachers will find the need to create or modify a program. Indications are that the current dearth of quality courseware is not likely to last indefinitely. We are currently witnessing a growth in the interaction between schools and developers that promises to bring more and better courseware. In addition, some authors (Ragsdale, 1982; Russ-Eft & McLaughlin, 1983) have suggested that standards in courseware development could lead to programs that are designed to be modified by teachers without the necessity for reprogramming.

To some extent, technical inservice training may be needed to supplement particular school needs. As stated previously, some districts have delegated hardware and courseware decision making to their schools. This suggests the staff gain familiarity with needs assessment and software evaluation techniques at the local level. Emphasis should be placed on gaining participation of staff in this training. Russ-Eft and McLaughlin (1983), for instance, have commented on the need to provide incentives to involve teachers in the software evaluation process.

There are other skills that can be included in the inservice program to maximize the use of computer technology, but which have yet to be addressed in the literature. There has been very little discussion of how educators can incorporate students' knowledge and abilities in the district or school plan, yet this is a potentially rich resource. Increasingly, students are bringing computer skills to the class which can supplement and enhance the computer services provided by the schools. Students can be used to assist in running computer labs or designing and modifying programs. They can also be used quite effectively as peer tutors within the classroom.

It is appropriate to include in an inservice program some time for educators to think creatively and critically about the use of the computer. By promoting educators' thinking beyond the "incidental computer instruction activities or experiments ...[to] establish a major role for the computer in the classroom environment" (Dennis, 1979) we will have reached a significant goal. Dennis calls this stage the "maintenance of growth stage" and suggests that it is where the computer-using teacher "comes of age." The educator assumes the initiating role at this stage, rather than being dependent upon the training program for motivation.

Designing effective training

It may be more important to identify what, in general, makes training effective than it is to recommend the particular content of teacher training courses. While the content of inservice programs may vary, the characteristics of "good" programs are more constant.

One of the most important characteristics of a good training program is that it instills the concept of "ownership" in the participants. Ownership, in this context, means that the participants feel that they are a constructive and integral part of the school system; that it is their system, and they should actively seek to improve upon it. Fostering ownership should be a goal of all inservice programs. Some educators who have not developed a sense of ownership have a feeling of guilt about their lack of involvement. Some disassociate themselves and then they can criticize "mistakes" that are made. Effective ways need to be found to encourage active participation.

As previously mentioned, lack of incentives has been cited as an issue that inhibits the education of teachers at both preservice and inservice levels (Milner, 1979). A diversified incentive program seems to work well. Some common incentives are paid release time, salary credit, and paid fees for conferences and college classes. It would be interesting to determine how effective particular incentives are for encouraging participation in computer inservice programs, and what additional incentives might be more successful.

A non-threatening training atmosphere is important. This can be accomplished though careful design of the course and dissemination of the information. Among the factors to be considered are the pace and scope of the class. Encouraging teachers to "spread the word" can help develop a friendly image.

The establishment of peer instruction approaches and support groups merit consideration (Hedges, 1981). The knowledge that there are others with whom one can share experiences and ideas can help to motivate staff. Teacher-user groups, within or among schools, can meet the need for peer support. Another approach is to have a team of qualified teachers travel to other schools to assist and motivate novices.

Hardware Considerations

The range of computer equipment available for school use is extensive and growing. However, very few schools that AIR staff have visited have equipment beyond the "standard" configuration of computer, monitor, and disk drive, whether it be in a stand-alone or network system. For example, in an entire suburban district in the Silicon Valley area we found only one touch pad. Despite the plethora of news releases about touch screens, voice recognition devices, and other advanced technologies, they either remain outside the financial reach of most district or individual school budgets, or awareness of their potential is lacking. That is regrettable.

In this section, we will discuss types of equipment and configurations that are most commonly used in the schools. Emphasis will be on stand-alone systems, networking systems, and selected peripheral equipment.

Stand-alone systems

The stand-alone computer system is one of two major types of computer configurations in the schools today. Originally, schools purchasing microcomputers had no choice but to buy stand-alone systems. At first, networking was not technically feasible, then it was too expensive for most schools. Even now that networked systems are a feasible alternative for many schools, stand-alone systems are often considered the most sensible first step in implementing a computer use plan.

The stand-alone system has some special advantages that make it very attractive to educators. One major advantage is the variety of computers that are available to purchase. When choosing computers for a networked system, alternatives are, of course, limited to those that can be interconnected.

A second major advantage of the stand-alone system is cost. Purchasing a small number of machines can be a cost effective of way of entering the computer era, although it will preclude the savings possible through large quantity purchases. Since purchasing computers is quite costly, schools are well advised to explore incremental purchasing plans with hardware vendors.

Equipment mobility is another factor influencing choice. Stand-alone systems are easy to share. Teachers can request that computers be brought into their classroom, rather than having to move their class to the computer lab. This is particularly important when there are multiple demands for the use of the computers and/or the lab.

A fourth consideration is that there is far more courseware available for stand-alone systems than for networks, because much existing courseware is incompatible with network systems. Schools must carefully decide what type of applications they will need. What the future availability of software will be for network systems is an open question. Educators indicate that concern with the availability of software has had a significant influence on their decision to use stand-alone systems.

Network systems

Networking has received a tremendous amount of positive publicity in the last few years. In our view, the future of this application for schools is very promising. A review of the some of the major issues and uses of microcomputing networks follows.*

Two typical types of computer networks can be identified: the local area network and the remote network. A local area network (LAN) is distinguished from a stand-alone system in that individual microcomputers are physically linked together through a master unit, or central source. The local area network requires that (1) microcomputers be linked within a given distance, and (2) no more than some maximum number of microcomputers be interconnected. (Connel, 1981, gives a description of the alternative networking systems.) A remote network, on the other hand, links computers using telephone lines and is not usually limited to a specific number or type of computer that can use it.

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*A more detailed analysis of networking is addressed in a separate CREATE paper, Existing and emerging technologies in education: A descriptive overview.

Local area networks. The local area network is the most widely used type of network in the schools. One of its advantages is that it can be a relatively inexpensive way to share resources within a school. Floppy disk type network hardware can be acquired very inexpensively. A teacher can then "upload" or "download" programs within the network through the master unit. The need for many backup diskettes is therefore eliminated. The savings on not purchasing backup diskettes can sometimes be more than the price of the network hardware.

On the other hand, courseware for the network system is more expensive than non-network courseware, which limits the range of choices for instruction. Licensing agreements also remain a barrier to schools seeking low-cost software for network use. This is a major problem that must be worked out if networks are to reach their full potential. Finally, programs that require frequent disk access may not function correctly when multiple stations are running.

It is easy for the teacher to manage some of the simpler network systems. In general, floppy disk networks do not require sophisticated training to operate. There are fewer diskettes to keep track of so there is less danger of courseware being lost or damaged. Teachers are able to quickly and easily arrange for students to access programs. In addition, teachers are able to monitor use within the network. This provides the educator with the opportunity to unobtrusively view each student's progress. Some network systems also have an optional management program that keeps track of various kinds of information for the teacher, such as how many times a student attempted a problem, how well the student did on an assignment, and so on.

The cost and technical expertise needed to operate some of the more sophisticated network systems, especially the hard-disk networks, are factors limiting their use by schools. Although the use of these complex systems will most likely become more common in the future, their use at this time may be impractical and unnecessary for many schools. The equipment is relatively expensive, and commits a school or district to following a more narrowly defined set of applications. The required training to operate the equipment can often lead to the appointment of a specialist. The other staff may become dependent upon that person when using the system. Unique maintenance problems can also arise which are beyond the capabilities of the school district. Many districts have chosen to acquire equipment that they are capable of maintaining themselves in order to ensure prompt, reliable, and inexpensive service.

Remote networks. The use of telephone "dial-up" devices (modems), which permit microcomputers to access other computers or databases has yet to make much impact upon elementary and secondary schools. Their use may increase in coming years. A recent AIR study of a modem-based microcomputer network (McLaughlin, et al, 1983) has indicated that schools lack sufficient expertise, time, and administrative leadership and incentives at this time to make effective use of these resources. The use of modems at the district level, however, may prove useful for relatively inexpensive and efficient information retrieval and exchange, either with schools or databases (Folke, 1983). In addition to the educational and technological information available through DIALOG and Bibliographic Retrieval Service (such as ERIC, PsychInfo, and the Microcomputer Index), databases specifically designed for general and special educators have been developed for use with the modem. SpecialNet, the Special Education Communication Network, is a database and bulletin board that is currently used by more than 600 local school districts and state education agencies. The Handicapped Educational Exchange (HEX) and DeafNet are two other on-line information resources particularly designed for use by the handicapped population.

Selected Educational Devices

It is appropriate to briefly mention some additional educational devices that have been used to supplement computer hardware. These devices represent some of the directions schools are likely to follow in adopting new technologies.

Several authors (Barnett and Better, 1983; Keller and Shanahan, 1983; Harris, 1982) have recently discussed how BIG TRAK, (a programmable toy tank with a simulated keyboard), and TOPO, (a small robot controlled by the keyboard of a computer), have been incorporated into the computer literacy program at elementary schools. These devices help children understand abstract concepts associated with programming by relating them to real life experiences--they provide objects to think with. BIG TRAK and TOPO are the kinds of instructional tools that facilitate the acquisition of skills involved in problem-solving, decision making, logical thinking, and mathematics.

Weintraub (1982) suggests that schools make more use of "dedicated" computers to teach basic skills and computer literacy. These computers are designed to perform a single function, and so no programming skill is required. Software either resides within the computer or is available in modules that plug into the computer. For example, Speak and Read, a low-priced dedicated computer for grades 1-3 that includes audio output, is available from Scott, Foresman. The advantages of these dedicated computers is that they are inherently motivational, inexpensive, light-weight, durable, and portable. They are also especially suited to individualized, self-paced study because levels of difficulty can be built into them.

Software Considerations

When schools decide to integrate computer technology into the curriculum they can easily overemphasize the importance of hardware decisions. Software considerations, in many cases, are made only after the computers have been purchased. There has been a general belief that good quality software would spontaneously appear on the market or that it would be a simple matter to produce it locally. This notion has largely been dispelled. There are many complex issues associated with integrating software into the curriculum and the decisions are not always easy.

In this section, we will discuss issues associated with software selection. Our aim is to pinpoint factors that should be considered in developing a comprehensive and effective software acquisition plan.*

*A more detailed discussion of software selection procedures is in a separate CREATE paper, The Evaluation and Selection of Instructional Software for Use with the Learning Disabled.

Software acquistion

The process of developing a good courseware library is to a large extent a function of the type of computer that will be used. For this reason, a key decision that must be made is whether priority should be given to determining the "best" computer in terms of cost and capabilities or to the computer having the most useful software. Schools have tended to give high priority to the computer when implementing a new program and sometimes have found themselves limited in their available courseware choices. Both the quantity and type of courseware vary widely by computer and operating systems, although there is some overlap. Thus hardware decisions can have a tremendous impact upon how computers are actually used in the schools. The availability issue also raises questions about whether schools should develop their own software.

A reasonable approach for schools, and one that is gaining more acceptance, is to first decide what the computers will be used for and then look at choices in software to meet those needs. That is, the computer use plan should suggest the types of courseware that will be acquired. Reviewing the existing relevant courseware should then influence what computer systems are finally selected for the school. This procedure can also reveal the best sources for acquiring software.

A very different approach to developing libraries of courseware is to deliberately employ more than one type of computer in the system configuration. One advantage of such an approach is that it increases the choices of available courseware. Because different pools of courseware exist for each computer, a better overall collection of courseware is possible with such a multiple computer design. Another advantage of this design is that it increases the opportunities for schools to (legally) exchange or share courseware with other schools and resource centers. Schools cannot be expected to acquire complete and self-sufficient collections of courseware because of the implied costs and duplication of effort. Having different machines helps schools meet their needs more efficiently. It also protects against problems inherent in relying upon one system, such as obsolescence or discontinuation by the manufacturer.

Delivery systems

An educational delivery system consists of two parts: (1) the physical objects and structures designed to accomplish a goal, and (2) the human culture in which learning takes place (Bunderson, 1981). The combination and interaction of these parts exerts influence on the way learning takes place. It also has an impact on the type of courseware that best fits into a school's curriculum. Courseware today is designed for either a teacher-centered delivery system or a student-centered delivery system.

Teacher-centered delivery systems have been and continue to be dominant in our school culture. Bunderson (1981) notes that this delivery system has been highly resistant to change. Because of this, it is difficult to think in terms of alternative delivery systems, let alone implement them successfully. The teacher model emphasizes the importance of learning theories, considering the delivery system as something to be dictated by the nature of educational objectives. The type of courseware that is most associated with the teacher-centered model can be described as an adjunct or supplement to the teacher (eg., drill and practice). This type of courseware is generally limited in its range of application. It rarely takes advantage of the full power of the technology, in terms of its teaching capabilities. Holmes (1982) feels that "any attempt at implementation of a CAI system is more likely to succeed if the system is viewed as a supplement to traditional modes of instruction" (p. 12).

The student-centered delivery system attempts to take advantage of the capabilities of the technology to individualize instruction in the most efficient manner. In contrast to the teacher-centered model, the student is given some degree of freedom to "design" the learning process. Exploratory learning environments, such as Logo, are most closely associated with the student-centered model. Implicit in this model is the importance of the technology or delivery system itself as a force in the learning process. Research has only begun to explore the applicability and utility of student-centered delivery systems.

Six common modes of instruction have been identified: drill and practice, tutorial, games, simulation, problem solving, and exploratory learning. The particular characteristics of each of these modes have been sufficiently discussed and documented elsewhere. Feurzeig, Horwitz, and Nickerson (1981), however, have identified three categories of instructional techniques: computer-controlled, user-controlled, and mixed initiative. The first two categories represent the current uses of courseware, while the third indicates a possible direction for new courseware development.

Computer-controlled instruction consists of drill and practice and tutorial courseware. It is closely associated with early programmed learning techniques. The student has only the option of responding to presentations; he or she cannot ask questions of the system. Most research on instructional courseware has been focused on this kind of application (Watt, 1982). A major advantage of this type of courseware is that it is easily produced, and therefore readily available. Proponents of this type of courseware have noted improved performance levels of students, particularly those below average achievement. However, it is not clear that significantly improved conceptual understanding of material can be achieved with this technique.

Student-controlled instruction presents learning as an active process of investigation. Central to this mode of instruction is the principle that the student is free to direct the learning process. The computer simply responds within its limits to the inputs from the student. Simulation and exploratory learning environments are examples of this type of instruction. They hold promise for the acquisition of fundamental concepts and relationships (Slesnick and Friedman, 1983).

The third mode, mixed initiative instruction, comes closest to approximating the dialog associated with the teaching-learning process. In this instruction, the student works on a problem solving task in which there may be multiple answers or no answer at all. The student again directs the learning process, but the program functions as a guide and critic for the student. These programs require substantial knowledge about the problem, as well as capabilities for understanding and responding to inputs. The strength of mixed initiative instruction lies in its ability to teach problem-solving strategies and techniques that may be useful in specific courses as well as across disciplines. The development of these systems has been linked to artificial intelligence, sometimes referred to as intelligent computer-assisted instruction (ICAI). Recent technological advancements have made the development of mixed initiative systems for microcomputers a real possibility. Blum-Cohen (1982) notes that there is a "great demand for programs which teach thinking skills, problem-solving techniques and higher order skills such as application and synthesis of concepts" (p. 64). There are very few of these programs available at this time; Robot Odyssey, from the Learning Company, is one example.

Local courseware production

Given the current need for quality courseware, especially in subjects other than math, science, and language arts (Russ-Eft and McLaughlin, 1983), the production of courseware at the local level has received renewed attention. Schools can develop courseware either through the use of authoring languages or through high level programming languages.

Authoring languages consist of two basic formats. One format provides a framework within which the user constructs a lesson by responding to prompts that are provided. The second format provides the user with a special set of commands to create their own framework. Authoring languages may provide other sophisticated features, such as sound capability and quality graphics. Authoring tools, particularly mini-authoring systems, are now widely available (Bockman, 1983). These tools provide provide the opportunity for rapid and easy insertion of content in a "shell" of courseware without the necessity of learning a programming language.

Producing courseware through high level programming languages provides true flexibility in design, but has severe drawbacks in terms of energy, and time required. There is disagreement over how cost-effective this approach actually is for local schools or districts. Holmes (1982) feels that the "size and composition" of the production teams have been exaggerated. He claims that there is evidence to suggest that "effective, motivational learning environments can be created using simple techniques" and that local resource personnel can be utilized for this purpose. Bunderson (1981) feels that although the costs decline as a function of experience they are still quite high.

Implications for CREATE

This paper has discussed the current state of school planning for and use of hardware and software. It has also addressed current practices in staff training and training needs. The findings have important implications for the field in two main areas: planning for systematic acquisition and implementation of new technologies, and leadership development for those involved in teaching the handicapped.

A major finding is that decisions regarding the planning and implementation of new technologies are moving out of the informal decision making process within districts and becoming part of the formal process. Until recently, most significant decisions to move forward in computer use have depended upon discretionary funds and have been prompted by individual effort at lower than district-wide levels. There is increasing recognition of the need for leadership and formal structures that can facilitate efficient information gathering, plannning, and decision making at all levels within the district. CREATE can provide assistance to schools by examining how exemplary programs have developed successful solutions to these requirements.

Patterns of organization of the new technologies within districts and schools have not been well researched or documented. Within districts, patterns have been influenced more by funding and logistic considerations than by school needs. Organization within schools has been mostly influenced by the number of computers available. CREATE could research the configurations of computer technology that lead to optimum use of the equipment and resources as well as equitable access to them by different student populations. In particular, the organization of resources for special education students calls for the examination of critical selection procedures as well as scheduling, motivation, and human factors considerations.

The literature on inservice training programs has concentrated on ways to introduce computers into the schools. This has taken the form of changing teachers' attitudes toward computer use, teaching computer fundamentals and software selection, and providing incentives to encourage participation. While this remains an important issue, there has not been much discussion or agreement on what specific kinds of training, other than programming skills, are appropriate beyond this introductory phase. It would be helpful to explore how training can be designed and organized to meet the needs of different types of teachers. In particular, the investigation should consider what the components ought to be in an effective training program for special education teachers. The focus should be on those skills and competencies that special education professionals ought to have in the use of computer technology, and then develop instructional strategies for teaching these skills. For example, the computers themselves would be used for staff development through simulation of cases. Although it is not within CREATE's present plans, such a strategy could enhance the quality of instruction while utilizing existing technological resources within the schools.

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