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RESEARCH MEMORANDUM

THE IMPLEMENTATION OF TECHNOLOGY IN SCHOOLS: LESSONS FROM EIGHT SITES

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ABSTRACT

This series of case studies was undertaken in order to identify the context variables that affect the implementation of technology in schools. The sites were selected to represent a range of applications of computer technology, and some variance with respect to the success of the technology relative to its intended use. Candidate sites were obtained through nominations by knowledgeable individuals and a review of the literature on technology in schools. Each site was visited by two investigators for periods of up to four days. Data was collected via observation and interview, for which a series of questions had been developed, and the review of relevant documents. Case studies of each site were prepared. The information collected across the eight sites revealed two predominant patterns of implementation of technology: a top-down approach, managed by the school and/or district and typically associated with an integrated learning system or other centrally-located installation, and a "grass-roots" or bottom-up approach, usually involving a variety of applications. The results also suggest that the <u>process</u> of implementation is best studied longitudinally, rather than in the cross-sectional fashion of the current study. An interesting implication of the results for developers of technology-based assessment systems was the finding, across all sites, that teachers did not routinely use or find helpful the many and varied progress reports supplied them by the technologies investigated.

INTRODUCTION

There is still much to be learned about effective ways to use technology as an instructional and learning tool, and experts disagree about the likely long-term impact of computers on education. A recent historical investigation of technology use in classrooms concluded that "the search for improving classroom productivity through technological innovations has yielded very modest changes in teacher practice without any clear demonstration that instruction is any more effective or productive after the introduction of radio, films, instructional television or computers." (Cuban, 1986). Despite this pessimistic appraisal, proponents still believe that "technology makes it possible to consider real improvements in the productivity of both teaching and learning." (U.S. Congress, Office of Technology Assessment, 1988). Whether today's "modest changes" become tomorrow's "real improvements" is uncertain; the experience of the past decade suggests that many problems will have to be solved before technology can become a widespread, effective educational tool. One of the first problems that must be solved if technology is to have a positive impact is the problem of implementation. The success of educational innovation is determined to a large extent by the nature of its implementation (Berman & McLaughlin, 1978; Fullan, 1982). The purposes of this study were to explore the contextual elements that are important in implementing technology-based change and to clarify relationships between the context, the of nature of technology, and the process of implementation.

PROCEDURES

Previous research suggested a number of factors that might be important in the process of educational innovation, particularly technological innovation. These factors included the nature of the innovation; the classroom and school contexts in which the innovation was taking place; external factors from outside the educational context; and the nature of the implementation process itself. In designing the study, we tried to be sensitive to these four factors.

In addition, we added our own concerns about the use of technology for the purpose of assessment. We were particularly interested in the role that technology can play in the measurement of educational achievement and in the integration of technology-based assessment into instruction. This expanded set of concerns became the basis for framing the study and identifying the specific issues to be investigated.

Research Questions

The major research question addressed by the study was: which contextual factors and conditions are related to the successful implementation of technology in schools? In order to organize data collection, six specific topics were delineated:

- The nature of the technological application

- The organizational and instructional context, including the physical plant and facilities; the administrative structures in place before, during and subsequent to the introduction of the technology; the curriculum and the style of instruction;

- The implementation process, including the history of innovation at each site, the current status of technology, and the plans for future use

- The use of technology for assessment

- Exogenous factors that affected school activities, staff and decision making

These topics became the basis for structuring the data collection activities.

Choice of Method

Despite growing interest during the past ten years in the use of technology in schools, there was little precedent for the addressing the types of questions we wanted to ask. Research on technology tended to be of three major types: large scale surveys describing technology use across a large number of institutions (e.g., Becker, 1985); documentation or evaluation studies of a particular technology (e.g., Ragosta, et al., 1984; Murphy, et al., 1985); or case studies of individual attempts to introduce a particular technology in a particular place (e.g., Stasz, et al., 1987). Few studies attempted to identify common threads across a range of different technology applications.

Although we started with some general ideas from the literature about what <u>might</u> be important variables in the implementation of technology, we did not want to limit our vision to these or to interfere with our ability to identify unanticipated outcomes. Moreover, our goal was to focus on the <u>process</u> of implementation, a focus that demands a methodology sensitive to questions of how and why, to the causes of events over time and to complex interactions among variables. For these reasons, we chose an approach that emphasized qualitative data and naturalistic methods rather than quantitative data and structured data collection. While budget constraints precluded longitudinal case studies, we tried as much as possible to incorporate case study methods. These included visits to individual sites, examination of extant data and reports, open-ended interviews with selected informants and, wherever possible, observation of the technology of interest in operation. Although we outlined common questions and procedures for data collection at each site, we also maintained flexibility in our data collection activities.

<u>Selection of Sites</u>

Our initial goal in this study was to examine a limited number of sites (eight) that represented <u>a range of technology products and applications</u> (from networked CAI systems to individual microcomputers with general purpose tool software) and <u>a variety of experiences with continuation and spread of use</u>. To this end, we searched the literature and informally surveyed individuals with knowledge of technological applications for an initial list of candidate sites. The inclusion (or non-inclusion) of specific sites had more to do with achieving a balance of characteristics across the eight sites overall than with the presenting qualities of any single site.

We intended to include sites that reflected a variety of hardware and software configurations (e.g., stand-alone microcomputers, networked computer labs, etc.), and a variety of different applications (e.g., CAI, simulations, testing, management, etc.). We also intended to choose four sites in which the use of technology could be considered successful and four that could be considered unsuccessful. This latter requirement turned out to be more complicated than we had anticipated because little consensus exists about what constitutes success with respect to the use of technology. Definitions of success are often site-specific and idiosyncratic. Moreover, few districts or schools were willing to say that their use of technology had been unsuccessful, and few of our sources of nominations were able to provide instances of uniformly successful installations. Consequently, we adopted continued or expanded use as an alternative for success as a selection factor.

We constructed a set of candidate sites according to these guidelines. The selected sites reflect different applications of technology (basic skills instruction, cross-curricular use of general purpose software tools, computerized assessment, etc.) and different hardware configurations (minicomputer-based networks, single application microcomputers, etc.). Half were identified as effective technology-based programs where technology use was growing and half represented "less successful" implementations of technology where use was declining.

Table 1 summarizes the distinguishing technological applications and characteristics of continuation/expansion that were the basis for selecting each site. Three of the sites represented traditional CAI applications in basic skills using minicomputer networks. Two sites featured multi-purpose applications of microcomputers across the curriculum. Three sites reflected specialized applications of technology -- one in the area of assessment, one in reading, and one using LOGO as a focal point.

INSERT TABLE 1 ABOUT HERE

<u>Data Collection</u>

The research topics shaped the development of interview guides and a protocol for observing the technology in use. The general approach was to speak with individuals who could shed light on each of these topics, and to observe technology use or technology-related activities both to verify the information we received and to enhance our understanding of the role of the technology in the school. At the very least, we asked to spend time at the site with (1) the individual who was currently responsible for the technology; (2) at least one building-level administrator who was familiar with the technology; (3) several teachers who used the technology; and (4) any individuals who were familiar with the history of the technology at the site. We also asked to observe as many instances as possible of the technology in use.

Interview guides were developed to provide structure for data collection. These semi-structured guides functioned to ensure coverage of the major topics. They were tailored to include questions on topics relevant to each respondent (see Appendix A). However, because not all respondents were knowledgeable about all of the topics, we were required to be quite flexible at the site in adapting the guides to different respondents. A very general guide for observing the technology provided a similar framework to ensure some similarity of data without being rigid.

Site visits were accomplished over a three-month period during the winter of the 1987-88 school year. Initial contacts were with districts, to receive permission to include a specific site in the study and to identify a contact person at each site. None of the eight sites selected for inclusion in the study refused us permission to visit, but we received different degrees of cooperation from individuals at different levels.

With two exceptions, both investigators visited all sites. During our visits to each site, we met with and interviewed as many of the individuals specified above as could be scheduled, either as a team or individually. We also observed as many instances as possible of the technology in use. In principle, we attempted to conduct our interviews in circumstances that would promote candor among our respondents. In practice, this was not often possible. In some instances, administrators insisted on being present for interviews with teachers; in others, the teachers and classrooms we observed had been preselected for us by the individual in charge of our visit.

Our goal in speaking to so many people was to obtain a range of perspectives about technological innovation. To the extent that we included individuals from different administrative levels and who represented different relationships to the technology of interest, we were successful in eliciting a range of perspectives. To the extent that individuals had been preselected or perhaps primed for our visit, we were less successful. These differences are reflected in the accounts of visits to the individual sites (see Appendix B).

We attempted to document the introduction of the technology: what technology use was like at the beginning, what the initial objectives were, when the introduction took place, on what scale, at whose behest, and to what effect. In most of the sites, this information was retrospective, obtained by asking individuals who had been present at the time of introduction for their accounts of the events. As a result, portrayals varied in accuracy and level of detail. In two sites, one of the authors had been witness to the initial implementation. While this fact may confound the results, details of implementation were available in the form of written reports, and these were used to cross-validate impressions.

Data Analysis

Throughout our visits and observations, we took copious notes. For example, we took written notes during interviews, documenting in as much detail as possible the events described and the activities observed. At the end of each day, each investigator wrote a summary of the experiences of the day, to elaborate on the notes from interviews and to describe the context and events in greater detail. As soon as possible following each site visit, each of the investigators transformed his/her notes into a narrative account of the site visit. The individual accounts were exchanged and inconsistencies in the separate perspectives were discussed and, where possible, resolved.

The actual data analysis was conducted in a semi-structured semi-impressionistic manner. The site summaries were reviewed and important characteristics of each location were noted. These included the nature of the technology, the salient elements of the local context, the process of introduction and implementation and the role of external factors. No specific coding scheme was used; instead the researchers abstracted key elements in terms that were meaningful for each site. After reviewing the summaries, the researchers discussed their impressions of the key features of each site as a means of cross-validating the summaries. When there were conflicts, field notes were consulted to resolve discrepancies. There were no disagreements that could not be resolved in this manner.

The data analysis proceeded in an interactive manner. Some themes and relationships emerged from review of the site summaries; others were suggested by the researchers and confirmed or denied by checking against the summaries. In this way the summaries served both as a source of ideas and as a data base against which ideas could be validated. One phase of analysis involved reviewing similarities and differences across sites and looking for patterns.

Another phase involved looking for relationships within each site and attempting to generalize them to others. Ultimately, the researchers made the final determination of whether a finding was valid or not based on their notes and understandings of each case and the pattern of results across cases. Only those findings that both researchers agreed were supported by the data are reported here.

RESULTS

In this section we summarize the circumstances that existed at the eight sites at the time of our visit and describe the results of our interviews and observations regarding technology use and implementation. The section begins with a brief acknowledgement of the limitations of the study. Following that there will be a brief summary of the sites and the technological applications being implemented in each. (More detailed descriptions of the individual sites are found in Appendix B. These summaries provide richer descriptions of the implementation process in each site as our informants reconstructed it.)

Following the brief description of the sites we present the results of the study in four separate sections, focusing respectively on the nature of the technology, the organizational and instructional context, the implementation process, and the external factors that affected actions in each site[1]. The divisions are parallel to factors that were identified in the literature review and include all the topics delineated in the research questions. However, the reader should be cautioned that the divisions are somewhat arbitrary. In reality, it was not always possible to differentiate phenomena so cleanly; situations spanned multiple dimensions, and elements interacted. Nevertheless, we found this scheme to be a useful organizational device.

In each section, we describe variables that differentiated among sites that might be incorporated in studying technology implementation. Where appropriate, we also discuss relationships between variables that are relevant to the implementation of technology. These represent some of the lessons we learned from the eight sites that might be more widely applicable.

Limitations of the Study

Before discussing the findings of the study, it is important to acknowledge its limitations. Our observations at the eight sites confirmed many of the results cited in earlier research. Specifically our observations suggest that the implementation process is an important (if not the most important) element in technological innovation and that this process is both complex and lengthy, lasting many years in the sites we visited. Furthermore, the nature of the technology, conditions within the adopting organization and the larger context in which the adopting organization exists affect both mode and progress of implementation and the ultimate institutionalization of the technology

These observations lead to the inevitable conclusion that the methodology of the study described here was not the ideal one. A better approach for gaining insight into a long-term process would have been a series of longitudinal case studies, involving data collected over extended periods of time. While a series of cross-sectional analyses of selected sites may be

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[1] There were very few instance in which technology was used for the purposes of assessment. Rather than creating a separate section, these results are integrated into the other discussion.

useful for exploring interrelationships by comparing and contrasting relationships across sites, it is probably impossible to study the implementation process thoroughly other than longitudinally.

Another caution that must be mentioned regarding the findings of this study relates to the unit of observation. Focusing on the school or the district as the primary unit of observation, as this study did, limited the attention that could be paid to variations among teachers in attitudes toward innovation and technology; in differences among uses made by individuals of the technologies observed; and in the adaptation and accommodation of and to the use of technology in different classrooms. Although it became clear to us quite early in the study that important differences existed among teachers in reactions to and applications of the same technology, we were unable to do more than acknowledge that such differences existed and were interesting in the interests of capturing school-level phenomena. An important next step will be to examine variations among teachers within schools, that is, variations among teachers with the effects of school-level variations held relatively constant.

Nonetheless, we were able to discern some relationships among features within sites, and some commonalities across sites. These are described in the remainder of the Results section. In the Discussion section that follows, we describe groups of variables that appear to have co-occurred in our sites and attempt to draw some methodological conclusions about studying implementation.

Site Descriptions

We found that the type and variety of technology use observed at each location did not always match the information obtained prior to visiting the sites. In most cases the identified application was not the single focus of technology activity, and in some it was not even the dominant application. There was much more diversity in the use of technology than had been anticipated. Consequently, it seems appropriate to begin the discussion of results by describing the type and variety of applications actually observed and discussed during the site visits. This capsule summary of the sites should provide a useful backdrop for the sections that follow.

Briefly described, the eight sites included:

- West City Street High School,[2] an urban high school in which stand-alone microcomputers had been introduced as part of a larger multi-site project to train teachers and provide them with a range of software to adapt to their own instructional needs;

- West City (CAI), a district in which computer-assisted instruction had been introduced into about a dozen schools in the late 1970s

[2] Pseudonyms have been assigned to all places and almost all commercially-available computer systems. Only IBM and Apple computers, the LOGO language and the Writing to Read Program are identified by name because of the unique characteristics of each and the futility of attempting to disguise them.

initially in the service of Chapter I instruction in the elementary grades;

- Valencia, a K-8 district that had enthusiastically adopted a networked integrated learning system (identified herein as NUTEC) as the first piece of a large, centrally-mandated effort to make itself a model of technologically-sophisticated education;

- Davis County, a K-12 suburban district that had designed its own district-wide, centrally-managed computerized reporting and assessment system;

- East City (Neptune), a sub-area of a large metropolitan district that had adopted a networked integrated learning system (herein called Neptune) dedicated to reading and mathematics instruction for Chapter I students;

- East City (Writing to Read) a school in a large city district that was one of the first schools included in a phased introduction of this computer-based beginning reading program;

- Lenape, a K-12 district in a small town that, having decided to integrate technology across the grades and the curriculum, had introduced a number of different applications and hardware configurations; and

- The Metro City Technology School, an alternative junior high school in a large city that was attempting to create "a LOGO environment."

The sites differed in other significant ways, including location, unit of implementation, grade level, curricular focus, and the characteristics of the students who were enrolled. Five of the sites were in major cities, one in a growing suburb of a major city, one in a small city and one in a small town. The primary unit of observation/implementation differed as well. At one end of the spectrum, in two sites the technology of interest was located in single schools, one a very small school. At the other end of the spectrum, the technology of interest had been implemented across the whole of a major city school district. Table 2 summarizes selected demographic and distinguishing characteristics of the sites.

INSERT TABLE 2 ABOUT HERE

There were also a range of grade levels and curricular emphases involved in the technologies of major interest to this study. In two sites, the major emphasis was on reading and mathematics instruction in the elementary grades for Chapter I students. In one site, the emphasis was solely on beginning reading for Chapter I students. In another site, the emphasis was on reading, mathematics and language arts instruction for all students in the (K - 8) district. In yet another site, the emphasis was on reporting and assessment in all subjects for the entire district, although the technology had been introduced only through the junior high school level. In the remaining sites, the technology was applied more diffusely: to different classes, depending upon the interest and sophistication of their teachers, to students in different grade levels, and for different subjects.

With a single exception, all of the technologies had been implemented in the early 1980s; the one exception was an early experiment in CAI. The latter had been implemented as part of an evaluation of the effectiveness of CAI; although the effectiveness had been demonstrated to the satisfaction of the sponsors of the study (and the technology had been more widely adopted by the city in which the study had taken place in a limited number of schools), a decision had been made to phase out the technology by the time of our visit. Table 1 above listed some of the salient facts of implementation; Table 3 summarizes the principal and secondary technological initiatives that were taking place at the selected locations.

INSERT TABLE 3 ABOUT HERE

There was considerable variation across sites in the degree to which and the manner in which the technology was salient to the curriculum. In at least three sites, the computer-delivered content <u>was</u> the curriculum, at least for the students involved in the grades involved. In other sites, the technology was employed as an adjunct or accessory to the curriculum, for enrichment or enhancement or for imparting experience with the technology itself.

As noted above, technology use in the sampled schools/districts was generally more diverse than had been anticipated. Though the sites had been selected on the basis of one primary application of technology, staff were using computers and other technology in multiple ways. While the primary application was, or had been, present at each site, many other applications of technology were observed. Table 3 illustrates the extent to which alternatives were being tried by staff and students.

In the sections that follow we will describe the impact of various clusters of factors on innovation. The first section examines the nature of the technology and its relationship to innovation. Following that, we describe the school and district context and the impact of contextual factors on innovation in the districts. Next, we focus on the process of implementation and relationship between this process and some of the other factors that have been identified. Lastly, external factors and their effects are described.

<u>Type and Variety of Applications</u>

Sites differed substantially in terms of hardware and software, i.e., the types of computers that were used and the purposes for which they were used. A number of features of the applied technology might have been associated with different patterns of implementation; candidates among these were the type of hardware, the size/extent of the innovation, the location of the technology, the assignment of operational responsibility to different members of the school staff, the content of the software, and the pedagogical approach inherent in the system.

However, the limited number of sites and technological applications included in the study made it impossible to explore fully all of the possible relationships among features of the technology and implementation. Only a few of the many possible combinations of factors were observed. As a result, it was not always possible to disentangle the effects of attributes that occurred together. In several cases there did seem to be a relationship between some characteristic of the application and the pattern of implementation. Thus, while direct comparisons among individual features were often confounded with other variables, some associations between applications and implementation did emerge.

The patterns described here were quite distinctive, but it was also not possible to disentangle the effects of individual features (of the application) from the contexts in which they occurred. For example, the complexity of the system appeared to be inversely related to level of training (teachers were not responsible for operating the computers in the Chapter 1 CAI programs). However, this relationship may have had more to do with how students were selected to participate in the CAI (pulled from regular classes), the existing model of interaction between regular teachers and resource teachers, the remedial nature of the software that did not require much teacher intervention, or the reluctance of teachers to venture into the technology realm, than on the complexity of the system, per se. More than anything else, the discussion that follows underscores the interrelatedness of the factors observed.

Finally, two clusters of hardware and software features seemed to recur frequently in the eight sites. The features seemed to define common models of technology use about which we could draw some tentative generalizations regarding implementation factors. These clusters will be discussed at the end of the section.

Hardware type and configuration

While much was made of the differences among brands of microcomputers, between microcomputers and minicomputers, and between stand alone machines and terminals connected on a local area network, we found that, at least at this level of analysis, the configuration itself made little difference in implementation. For example, while there were significant differences in implementation between the network-based applications (as in Valencia) and the stand-alone applications (such as East City-WTR), the difference did not seem to be based on the nature of the interconnections between and among the units. To the degree that one arrangement was more complex than another, training may have been more extensive and additional support personnel may have been provided. However, there was little or no relationship between hardware differences, per se, and implementation.

Hardware complexity

On the other hand, it appeared that the complexity of the technology affected the pattern of implementation. This was apparent in the ways the schools were organized to accommodate the technology, particularly the roles and responsibilities of teachers. An example may clarify this relationship.

Local area networks (terminals or microcomputers linked to a minicomputer hub) are relatively complex to operate and maintain. Districts that adopted such systems, such as West City CAI and East City, developed procedures to insulate most teachers from the operation of the systems. The teachers did not visit the CAI labs nor use the computers on a regular basis; this responsibility was assigned to a resource teacher or a lab technician. The classroom teachers received printed output and verbal feedback from the resource teachers or lab supervisor. As a result, classroom teachers did not need to be trained or supported as computer users and system implementation was simplified in many ways.

Similar mechanisms were instituted in other districts using complex systems. For example, clerks were trained to help teachers interact with the minicomputer-based assessment system (Davis) and a lab technician assumed responsibility for operation of the CAI system (Valencia).

<u>Hardware location and organization</u>

The most common method of arranging computers and organizing their use was the computer laboratory. The major alternative was to distribute computers in smaller numbers in individual classrooms. Did the choice of location and organization, in and of itself, have a specific impact on implementation? Probably not. Labs were employed in different fashions based upon the philosophies of the schools and/or districts and the curricula they served, and these characteristics were more directly related to implementation than the physical arrangement of the computers. For example, in Valencia the computers were used to serve the skills-based district-wide curriculum <u>for all students</u>; in East City, pullout labs also served a district-wide skills-based curriculum, but only for Chapter 1 students. The close link to the curriculum affected the manner in which teachers were introduced to the technology and their continuing roles vis-a-vis the computers far more than the use or non-use of laboratories.

In Metro City and Lenape, on the other hand, the computer labs were not tied directly to curricula, in part because systematic sequenced skills-based curricula did not exist in either place. Instead, the labs were used to fulfill a range of instructional objectives in each place. This necessitated greater changes on the part of teachers, which, in turn, had direct consequences for implementation.

It is difficult to disentangle the location of the computers from other elements of the applications that were observed. For example, CAI was always delivered in laboratories, while cross-curricular infusion necessitated a more uniform distribution of hardware across the school. Location may be relevant to implementation, and it certainly warrants further investigation, but the differences that were observed in the sites were probably related more to the nature of the application than to the location of the computers. A study in which the individual classroom is the primary unit of observation may, however, suggest a different conclusion.

Size of the installation

Similarly, the size or magnitude of the installation appeared to be related to the pattern of implementation. The larger or more extensive the implementation, the greater the cost, the greater the need for coordination of effort, the greater the numbers of individuals involved in the process, and the greater the need for coordination and centralization. Grass-roots implementation seemed to characterize smaller units (The Metro City Technology School, Street School in West City, and Lenape, the smallest district included).

Scope/saturation of the innovation

The proportion of students in the school who came into contact with the computers was related, at least indirectly, to the way in which technology was implemented. When computer use was limited to a subset of students (as in the Chapter I arrangement), less accommodation was required by the school and the teachers. Where all or most students were provided with computer access and/or experience, more profound changes needed to be made in school schedules and curriculum sequences. This required more training, more changes in scheduling and organization, and greater levels of on-going support. Similarly, when the use of particular applications was limited to specific classrooms, little reorganization was required outside of those classrooms.

Degree of direct teacher operation of technology

The relationship between the degree of direct involvement in operating the computers on the part of teachers and the strategies that were used to promote and support implementation appeared to be strong. In some sites (Street School, East City-WTR) teachers were directly involved in the operation, coordination and use of the equipment. In others (East City-CAI) resource teachers, aides or technicians were the only staff who interacted directly with the machines and/or supervised student users; teachers had only indirect contact through formal or informal reports. The remainder of the sites represented points in between these extremes: support staff were responsible for the operation of equipment but teachers supervised and observed students (Valencia) or coordinators introduced lessons while encouraging teachers to become familiar with the computers and assume responsibility for the application (Lenape).

Operation of computers was definitely a hurdle for staff that had to be accommodated as part of the implementation process. The districts that adopted systems based on minicomputer networks arranged to free teachers from operational responsibilities by hiring non-teaching staff or by organizing the program so only one or two teachers had to be proficient in computer operation. In contrast, technicians were seldom provided for microcomputer laboratories and this posed a problem for many teachers. In general, when given the choice (Davis County, Metro City) many teachers opted to have nothing to do with operating the technology. In Davis County, the majority of the teachers relegated the entry of student data to paraprofessionals. The implementation process had to be responsive to the needs of teachers and these needs differed dramatically if teachers had to learn to operate the equipment themselves in order to understand the application and/or were responsible for operating equipment each time students used the application.

Clusters of technology applications

The eight sites could be aggregated into three distinct clusters based on the nature of the computer application (see Table 4), and each type of application was characterized by an identifiable constellation of features, e.g., hardware configuration, instructional approach, operational responsibility, etc. There also appeared to be clear relationships between these types of applications and the implementation process. The three types of uses were:

- Comprehensive, curriculum-specific instructional systems (commonly referred to as Computer Assisted Instruction or CAI)
- Adaptable tools and tutorials (that had to be incorporated into classroom lessons; including general purpose tools, such as word processors, spreadsheets, etc.; programming languages used in open-ended exploratory ways, such as LOGO in a discovery environment; and lesson specific software, such as single topic tutorials or simulations)
- Student assessment and reporting systems (observed in only one site)

Schools and teachers were required to adapt their programs to accommodate each of these types of systems. It was noteworthy that the nature of that adaptation was similar for schools adopting a particular type of system and was different for different types of applications. Patterns of use and strategies for implementation also differed for these different types of systems. The greatest differences in use related to the proportion of the instructional program affected by technology. The most obvious differences in implementation, at least as recounted in the course of our visits, related to the amount of training and continuing support.

Patterns of use. To a large extent the CAI systems were implemented as "stand-alone" units that replaced an existing instructional sequence in a subject. They were designed to cover one or more curriculum strands comprehensively, and to assume a major part of the instructional role.

In contrast, the adaptable tools and tutorials were typically "supplemental" to the existing curriculum and required continuing integration into the instructional program. The application did not provide comprehensive curriculum coverage by itself, and teachers retained responsibility for weaving the computer applications into the instructional program at appropriate times.

Finally, the single example of an assessment and reporting system was perceived to be a management tool rather than an instructional one. It was relatively limited in scope and its role was well circumscribed. Teachers incorporated it into student testing and record keeping activities to the extent they saw fit.

Strategies for implementation. CAI systems were installed with somewhat less training, and considerably less continuing support for teachers than the other two types of systems. This was not unreasonable, because the CAI systems made lesser demands on teachers, particularly when used in the pull-out mode that characterized most Chapter 1 programs. (One exception to this pattern was Valencia, where teachers were required to accompany their students into the lab. Even there, however, few teachers became conversant with the system itself, as opposed to the lessons offered their students).

Adaptable tools and tutorials were accompanied by the greatest amount of training, assistance, and continuing support. To be effective with this type of application, teachers had to be much more familiar with the operation of the computers and the applications being used than they did in the case of CAI. This occurred because the teachers usually were responsible for training and supervising students as they used the adaptable tools and tutorials. Furthermore, to the extent teachers embraced this type of application, they had to make the most significant changes in their routines and behaviors, e.g., to adapt their lessons.

Assessment and reporting systems may be the easiest to implement. Certainly, less training and ongoing support was needed and provided in the instance of the single assessment and reporting system we observed. This system had some of the features of each of the other two types of applications. As with adaptive tools, teachers were required to change their routines on a regular basis. As with CAI systems, teachers were insulated from operation of the hardware, although not intentionally so. In the district visited, few teachers actually embraced the assessment system enthusiastically, and the level of use was relatively low.

Summary

The type of technology used, the way it was organized and the nature of the application all appeared to be associated with different patterns of implementation in the sites that we observed. The interrelationships among these factors were complex, and it was not possible to disentangle the effects of each individual feature of the technology, especially as the information about the implementation process was largely reconstructed. Nevertheless, the features that appear to have the greatest effect on implementation were the degree to which teachers were involved in the operation of the technology and the complexity of the application.

School and District Context

How did the existing conditions in the sites affect the implementation of technology? Which aspects of the school and district context appeared to be relevant to the implementation of technology in the sites we visited? Context is a fairly general term. It is used here in its broadest sense to include such things as facilities, administrative organization, scheduling, staff capabilities and responsibilities, curriculum, instructional program, history of technology and innovation in the site, and governance. Although each of these issues is discussed individually in the following sections, features of the context occurred in combinations in the observed districts, and it was seldom possible to make direct associations between individual features and implementation.

Facilities

Physical structures and the need to accommodate equipment, provide electrical connections, alter the use of existing space, etc. affected the implementation of technology in all of the sites we observed. The earliest instance of implementation in this study -- the introduction of CAI in the West City schools -- produced the most physical disruption, at least in part because technology was newer then. Major bugs had not been worked out of the hardware, and the installation required some rather radical reorganization of space and realignment of facilities. As a consequence the implementation process was lengthy, disruptive and engendered both anticipation and trepidation on the part of staff. This was a good example of how physical changes could dramatically affect staff reactions to the technology. In Metro City and the original West City CAI sites, the introduction of large-sized computers into old-fashioned school buildings was time-consuming and intrusive.

As computers have become more common in schools and their size and power requirements have shrunk, it is undoubtedly the case that installation has become more routine, and the pain of that initial plunge has been reduced somewhat. In Valencia, for example, the most recently installed labs were welcomed, and their installation was much smoother than the installation of the initial labs. Similarly, a new school in Davis Co was constructed with the use of technology in mind. The amenities of the physical plant made the technology seem more at home and reduced some of the pain of implementation.

Even in the best cases the structure of the existing physical plant affected implementation, as it will in any other location that chooses to adopt technology. As technology becomes more common and educators have had more opportunity to learn from the experience of the past, they should be able to make more informed choices that take account of existing facilities. In this way, they will be better able to reduce the disruption caused by the introduction of new equipment.

Administrative organization

The introduction of computers into the schools was also accompanied to some degree by disruption to the existing administrative organization. Modifications had to be made to pupil assignments, schedules, class groupings, use of facilities, etc., and all of these factors had to be considered during the implementation of the technology. In many cases, organizational changes were consequences of unanticipated problems that arose as the systems were being implemented; in others staff were familiar enough with technology to have recognized the need for such changes ahead of time. Past experience with technology provided some districts greater foresight than others.

For example, the introduction of CAI in West City in the mid-1970s had created major disruptions to schedules and classroom routines. The only room that could accommodate the lab was located on the second floor, and students had to be moved great distances to take their turn on the machines. This was an elementary school, and children in the lower grades were not permitted to go up and down stairs, so they were not given a chance to use the equipment. Furthermore, because of the disruption caused by the distance to the lab, classes were moved as whole groups, even though only half the students were able to use the computers at a time. The other half had to be engaged in other activities while they waited their turn to use the software. All of these administrative issues had to be addressed during the implementation of the system in West City.

By way of contrast, the introduction of Neptune in the East City system, which occurred fully five years later, was less eventful. There were fewer machines per laboratory, which permitted greater flexibility in choosing locations. The computers could be installed in into existing Chapter 1 labs. Students continued to be scheduled and served in the same manner as they were under the extant Chapter 1 organizational structure. Still, the arrival of the computers required some rearrangement of the rooms and the development of a management plan that integrated the computer-based instruction into the existing curriculum and schedule. In these ways and others the existing organizational structure in the school affected the implementation of technology.

It is interesting to note that although the technology often required some modification of physical and/or organizational structures, there did not appear to be any profound changes in the way in which the business of education was conducted in the eight sites. With one or two exceptions, the advent of technology did not appear to have precipitated major changes in the essential arrangement of the schools we visited, nor in the ways in which those schools operated. Except for the single (Davis County) school that had been built to accommodate technology, we witnessed no examples of "technological revolutions" in the organization of schools. Less can be said about changes to individual teachers, though most of those we interviewed also appeared to be conducting their business as usual.

<u>Scheduling/access</u>

One consequence of choices made about the location and organization of the computers was the way in which the schools provided access to the technology for those who needed and/or wanted it (teachers, targeted students). It was clear that different arrangements of the technology affected the uses that students and teacher could make of the technology, but it was not clear that this feature was directly related to implementation.

In Valencia, for example, where all classes and all teachers spent time in the labs, initial attempts at distributing the hardware (and software) to individual classrooms had not been entirely successful. Moreover, teachers who wanted control of the technology for their own classes were becoming restive because of the centralized management of the labs and the priority that school-based instructional goals had over those of individual classrooms. At the opposite extreme, a lack of central authority over the technology in the case of Street School meant that there was no real mechanism for scheduling individual classes into the labs and many teachers stopped trying to use the computers because the arrangements had become too cumbersome. Even in a small school like the Metro City Technology School, as more teachers wanted access to computers for their own purposes, scheduling became more of a hassle.

Staff Capability and Responsibility

Both the capabilities and the responsibilities of existing staff affected the manner in which technology was implemented. The most obvious consideration that had to be paid to these contextual factors was in the area of training, but they also affected decisions about hiring new staff and restructuring the roles of existing teachers and support personnel.

The most apparent sign of changes in roles and functions was the creation of new jobs to support the computer innovation. The districts that installed laboratories of computers often hired a new person to supervise the facility and the equipment. Districts with other types of installations hired individuals to oversee the installations. For example, a laboratory coordinator was hired to supervise the operation of the CAI system (Valencia) and a technology coordinator was hired in Lenape to introduce and support technology use in the district. In some instances these individuals' primary responsibility was the operation of the system or the machinery, in other cases they had instructional or supervisory responsibilities as well. In either case, their existence often eliminated the need for teachers to become expert in the operation of the technology.

The most common new position was computer/technology aide. Most, but not all, of the laboratory aides were non-certified personnel; laboratory aides or technicians were most common in sites using minicomputer-based CAI systems. They, too, functioned to reduce or eliminate entirely the need for teachers to operate machinery. In contrast, the sites with distributed microcomputer-based applications either added no new staff or they added certified individuals in coordinating positions (e.g., Lenape). In these sites, teachers had to assume the responsibility for computer operation.

While not all districts hired additional staff, all accommodated technology by changing the responsibilities of existing staff. The most apparent changes were those involved in the coordination and operation of a large facility, such as a technology laboratory. Such a facility required full-time management, and the managerial functions had to be assigned to someone. However, even in cases where there was no laboratory, staff responsibilities changed in observable ways in response to the introduction of technology. For example, a teacher was freed from classroom responsibilities for one period each day to promote the computer-based assessment system (Davis Co).

In a minority of cases, the technology promoted fundamental changes in the way teachers carried out their instructional program (Valencia, Metro City), though such changes were discussed more than they were actually observed and usually affected a small number of teachers relative to the total staff.

Finally, in many cases the technology and the experience it created provided new professional opportunities for staff outside of the school. For example, in West City Street School three of the five members of the "core" group had taken new district jobs with greater responsibilities. The exposure to technology and to administration increased their expertise and they became attractive candidates for other positions. Expanding horizons for teachers created an implementation problem for sites that had to adjust to the loss of key staff. Although this situation occurred in only a small number of sites (West City Street School; West City CAI; Metro City), it created major problems in those cases, mainly in relation to continuing support to other staff in the use of the technology.

Curriculum Match

As noted earlier, the eight sites reflected considerable variation in the extent to which the new technology was related to the existing curriculum. At one extreme (Lenape) hardware and software were not introduced unless they served some extant instructional goal. At the other (Metro City) curriculum was created around the computers. In between were districts in which the technology and the curriculum enjoyed a "chicken-and-egg" relationship: Valencia, Neptune, Davis, and West City CAI. For example, Writing to Read (East City) represented a significant departure from long-standing instructional patterns, but with small modifications to the school curriculum, teachers accepted the innovation and even came to respect its effects. However, they were loath to give up their traditional modes of instruction, and petitioned (successfully) to retain the use of basal readers along with Writing to Read.

Many of the districts adopted technology with the specific purpose of supporting their existing curriculum. In fact in the cases of Neptune in East City, NUTEC in Valencia, and the assessment and reporting system in Davis County, the manufacturers of the technology made design modifications in response to specific requirements of the curriculum in the district. The Davis system was designed by the company with the district curriculum in mind, and the technology and the curriculum were introduced roughly simultaneously. NUTEC and the Valencia district each made some modifications in objectives and the sequencing of these to enhance the fit between the system and the Valencia curriculum, and the Chapter 1 objectives of East City and the Neptune system lessons had, over time at least, undergone a similar process of mutual accommodation. Similarly, the original installation of CAI in West City was undertaken because it was believed that the NUTEC curriculum offered drill and practice in the same essential skills that Chapter 1 funds were intended to build.

In contrast, some of the initial resistance on the part of teachers to the Writing to Read program (in at least the one school that we visited) was based on their contention that the program took time away from the required curriculum in reading and math. What ultimately inspired the teachers' support was their discovery that the Writing to Read curriculum was helping to improve students' reading skills as defined by district curriculum as well.

The introduction of technology that was closely linked to the existing curriculum appeared to have required less elaborate and lengthy implementation than the introduction of technology that fostered new curriculum. There were three interrelated reasons for this. First, technology that directly supported the existing curriculum demanded less new learning on the part of teachers than technology that stretched the curriculum, and hence less training was required. Second, the closest links to the curriculum occurred with CAI systems, and these were usually implemented in laboratories with resource teachers and/or technicians to operate the equipment. Teachers did not have to interact directly with the systems, and thus did not have to be trained to use the new technology. Third, these curriculum-related CAI applications tended to be operationally "compartmentalized" under the responsibilities of resource teachers or aides, so teachers did not have to make major changes in their routines. In the schools we visited, the applications that seemed most firmly established were those that were most integrated with existing curricula or that served particular curricular goals (Valencia, East City Chapter I).

In contrast, staff roles and responsibilities changed more and much more training was required in those sites that adopted cross-disciplinary applications and applications that focused on integrating computers into the curriculum in new ways (Street School, Lenape, Metro City). Our observations across sites suggest that innovations that necessitated changes in curriculum were more difficult to implement. These innovations required much more extensive training, created unanticipated tensions and changes in teachers' roles, and necessitated more elaborate continuing support. At the same time, there was greater overall direct use of technology by teachers (and greater variation in technology use between teachers) in sites that adopted applications that did not fit neatly into the existing curriculum.

One specific curriculum-related aspect of the innovations that seemed to affect implementation was the degree to which each application spanned one or more well-defined curriculum areas. Contrary to what one might expect, more comprehensive systems were "easier" to accommodate than less comprehensive ones. They could be substituted for existing units, and thus required teachers to do less to customize their instructional programs. Similarly, applications that addressed a specific well-defined topic or a few well-defined topics were more easily integrated than those that partially addressed many topic areas. Systems that demanded extensive curriculum adaptation were more difficult to integrate into lessons and required greater planning, adaptation, support, etc. The Metro City experience with LOGO offers an instructive example of the latter.

Instructional Match

The degree to which technology supported existing patterns of instruction appeared to have had an effect on the implementation process. We speculated that, like most people, teachers are loath to give up behaviors (teaching plans, instructional techniques and methods, etc.) they have refined over years of use, particularly if the behaviors achieve intended results. The degree to which a technological innovation supports (or at least fails to interfere with) established instructional routines and objectives may well affect the ease with which a particular technology can be implemented. For example, in East City, the Neptune system was plugged into an existing Chapter I pullout structure and was embraced by administration and teachers alike. Similarly, in Valencia, although teachers were required to accompany their students to the labs and circulate as the students worked, they did not have to change their behaviors in their own classrooms (save to eliminate some drill and practice) as a function of the computers. Both of these implementations occurred relatively smoothly.

The innovations that forced changes in instructional patterns encountered greater resistance and the implementation process became more complex. The Writing to Read experience in East City was a case in point. Despite their initial doubts, teachers ultimately accepted the innovation, though it required changes in their instructional routines. This acceptance came only after a lengthy implementation phase marked by extended negotiations about how to accommodate the system into the school. Ultimately the teachers were won over by the achievement gains shown by students.

History of Innovation

It seemed that much of what could be done at a given site was related to what had been done, successfully or unsuccessfully, in the past. The amount of variation among the districts in this study and our limited access to the history of technology in each district precluded any generalizations about the influence of different past experiences on technology implementation. However, it was quite clear that past difficulties were remembered and could pose additional obstacles to implementation of innovations, technological or otherwise. Similarly, success with technology in one setting could be used by effective administrators to smooth implementation of technology in other settings.

Governance/Leadership

Implementation of technology appeared to be enhanced by strong supportive leadership, both at the level of the individual site (school) and in the larger organizational structure (district). In those places where technology was embraced by leaders with authority, the implementation tended to be very directive and proceeded more smoothly than in sites in which individual initiative was relied upon to move things forward. This observation is consistent with the findings of school effectiveness studies, in which strong building-level leadership in the area of interest invariably emerges as one of the most important factors related to school effectiveness.

The eight sites offer compelling evidence of the importance of strong leadership in the continuing use of technology. In several of the sites, the fact that technology had taken hold could be attributed directly to the existence and persistence of strong leaders. The failure or discontinuance of the use of technology in several of the sites could be attributed directly to the decisions of leaders or to the loss of particular leaders who had introduced or been champions of the technology.

Valencia is a prime example of the role of strong leadership in introducing, maintaining and expanding a vision of technology in schools. Here, the vision of the superintendent and associate superintendent of a creating a district known for pioneering technology district was served by some fairly heavy-handed manipulation of resources. Building leaders were chosen and appointed for their support of the technology initiatives. On several occasions, the teachers' union was circumvented. The NUTEC coordinator was given extensive authority, and teachers were rewarded in terms of resources, release time, and recognition, for becoming involved in technology projects.

Street School provides an example of what can occur when leadership is withdrawn. Once the original group of project teachers moved on to other positions and the principal changed, the original IBM computers became part of the school's computer or business departments, and the initiatives of the project virtually disappeared. Individual teachers continued to explore technology in scattered corners of the school, but the intended diffusion of technology clearly had not taken place.

Metro City offers yet another scenario. When the strong leader whose efforts had created the school lost interest after the first semester of its existence, the Technology School floundered, leaderless, for a number of years. Ultimately, the small staff collected itself and worked together to develop a curriculum that bore little resemblance to the original grandiose plan that secured its initial funding. Although the teachers at the school seemed reasonably satisfied with the progress they made toward educating students in a difficult environment, the school never achieved the destiny its original leader had identified as "The School of the Future," a computer- and technology-intensive environment.

In the case of technology, both active participation in the innovation and the demonstration of administrative endorsement appeared to be associated with more effective implementation. Endorsement took many forms, but the most potent seemed to be the commitment of resources and the establishment of reward structures for those who adopted the innovation. While related, resource commitment and reward structures were not necessarily the same. For example, in one site (Davis County) financial support for the technology continued even as rewards for its use diminished. When the latter form of "championship" was withdrawn, use was noticeably curtailed.

In other sites, administrators who supported the use of technology established rewards for successful users, which facilitated implementation (Valencia, Lenape). When the administration was indifferent to the introduction of technology, users were less likely to be recognized or rewarded for their initiatives. This had a negative effect on implementation. This was clearly evident in Street School in West City, where a new principal was less enthusiastic about the technology initiatives that had been encouraged by the predecessor. As official encouragement and recognition diminished, implementation faltered and the overall level of use declined.

Finally, the support of the school board was critical in districts that made major investments in technology. Certainly, in the smaller districts (Valencia, Lenape) the attitude of the school board appeared to exercise a direct influence on the implementation of technology. In both sites, district administrators cited the support of their school boards as important elements in their success in implementing technology broadly in the district. In Metro City, where the Technology School depended on the advocacy of a single individual at the district office, the very existence of the school seemed threatened from year to year because of other priorities of the board.

Summary

The existing school and district context affected technology implementation in all of the sites that were observed. The interrelationships among contextual factors were complex, but the site visits illuminated some of the ways in these elements influenced the implementation of technology. The features that were the most strongly related to implementation in these eight sites were the match between the technology and the existing curriculum and instructional patterns, the pattern of governance (particularly the degree of administrative support and leadership) and the degree to which teachers' roles and responsibilities had to be changed to accommodate the new systems. Implementation was more difficult when significant changes were required in curriculum, instruction, and responsibilities. In such cases strong committed leadership, with firm backing, was able to create a climate to foster change.

The Process of Implementation

The implementation of technology-based change in the eight sites that were studied was a lengthy process. It began with the decision to introduce technology; followed by negotiations about what technology to employ, the actual physical changes wrought by the technology, the training of staff, the re-alignment of schedules; and continuing to the point at which the technology becomes integrated into the life of the school in whatever fashion was intended or evolved.

Although the focus of this discussion is the implementation of technology in schools, the study took place well into the process in all cases. Site visits were made long after the initial decision to adopt the technology; in at least one case (West City CAI), use of the technology of interest had been discontinued by the time of the visit. Information about the implementation process was therefore reconstructed from available sources: written accounts, the memories of those involved, and the status of the technology at the time of the visit. The accounts derived of the actual implementation process are uneven (see the site reports in Appendix B): in some sites, fairly complete information was obtained in the form of written reports or the recollections of key actors; in others, the process was recalled from memory.

It is, nonetheless, possible to identify some common elements in implementation across the sites. The eight sites represent a fairly broad range of implementation scenarios, from the essentially top-down approach of Valencia and the East City public schools to the self-definition of the Metro City Computer School; from the dedicated objectives-based approaches of the Neptune system in East City and the NUTEC system in Valencia through the across-the-curriculum approaches of Lenape, Street School and Metro City; and from the one-time large-scale installations of the West City CAI and East City Neptune systems through the evolutionary processes exemplified by Lenape and Metro City. This section discusses components of the implementation process at the sites, including the training that took place and the continuing support that sites provided for the technology following the initial stages of adoption. The section also describes recurring patterns or styles of implementation.

Training

All the sites seemed to recognize the importance of training in the introduction of technology. In all of the sites visited, teachers had been trained to some degree or other in the use of the technology of interest. For the larger systems, like NUTEC, Neptune and Writing to Read, training was part of the acquisition agreement. The West City-CAI lab managers received intensive training at the outset. Continuing inservice was also provided as part of the Neptune and Writing to Read agreements. In Valencia, the NUTEC coordinator had attended an intensive course at NUTEC; she, in turn, trained new lab managers on an ongoing basis. Davis County had established training as a district activity, created a training center at the district, and trained teachers and paraprofessionals at selected schools each year.

In Lenape, where there was no single technology in which to train teachers, individual teachers were encouraged to take courses wherever such courses could be found: at local colleges, for instance, at which their fees were reimbursed; and through inservice courses in various software applications provided by the district. The five Street School teachers had been trained in the initial phases of the project; it was expected that they would train other teachers. In Metro City, the original core of teachers was chosen -- or volunteered -- by virtue of their familiarity and involvement with LOGO. They and teachers hired later were encouraged to attend LOGO workshops, seminars, and conferences; many did.

In short, the implementation of any innovation implies new procedural knowledge on the part of potential users. All of the sites visited recognized the need for training of users and made arrangements for staff to be trained, centrally or by sending individuals to training courses. In several instances (West City Street School, Valencia), on-site personnel were trained to train others; in some cases, the training was provided by the purveyor of the technology (Neptune, NUTEC, Writing to Read).

Continuing support

All of the sites evidenced some degree of continuing support for the technology of interest, but the nature and quality of this support varied. The support involved both the hardware and the software as well as general hand-holding among teachers who were not totally comfortable with technology.

For example, the distributors of Neptune and NUTEC provided a telephone "hotline" users could call with even the most minor problems. The Chapter I teachers and their aides in East City all expressed gratitude for the Neptune hotline, because all of them claimed to have been computer illiterates prior to their training. In addition, the area Chapter I administration in East City and the NUTEC coordinator at Valencia provided ongoing support for resource teachers and lab managers, respectively. The NUTEC coordinator was able to repair minor malfunctions of the system herself, used the hotline whenever she needed to, and claimed to receive quick service when she needed it for major problems. Teachers whose classes visited the Writing to Read labs were not required to interact much with the technology, since there were lab assistants who performed the set-up and maintenance functions. Support for these teachers took the form of district or area-wide workshops and meetings attended by teachers using Writing to Read. The teachers found these to be good sources of new ideas for classroom activities to support writing. In Lenape, the technology coordinator ran a one-person support operation, providing encouragement, software, and information about and funding for training, as well as maintaining and repairing equipment. Undoubtedly, these support systems contributed to the smooth functioning of the technologies in their respective installations. Certainly the lack of ongoing support seemed to have accompanied the downfall of technology in sites where lessened or discontinued use of technology was observed (Street School, West City CAI, and the Metro City Technology School).

In Metro City, there was little formal support for the technology once the original organizers lost interest in the experiment. Hardware problems that plagued the rebuilt computers during the first year were handled on an ad hoc basis until two teachers and the coordinator became skilled at repairing the machinery. For the first two years of its existence, the school was visited at irregular intervals by staff from a major university, although these visits received mixed reviews from the teachers. Neither the university consultants nor teachers at the school seemed to know how best to take advantage of the visitors as resources. Individual teachers made some efforts to attend courses offered in and around the city and an annual LOGO conference at MIT, but these did not serve the central mission of the school.

The Street School project also exemplified the negative effects of a failure to provide continuing support for technology after the formal training project ended. Over time there was a gradual eroding of participation and narrowing of the use of technology. The original technology was simply incorporated into other functions at the school.

Ongoing support also appeared to have played a key role in the continued use of the technology in the sites visited. In sites where support was maintained at a level similar to the level at implementation, technology use appeared to have flourished. In sites where support diminished or disappeared completely, technology use faded as well.

Patterns of implementation

Across the eight sites, there appeared to be two predominant patterns of implementation, each with local variations. On the one hand, there was implementation that was essentially a top-down phenomenon, based on some central decision-making process and administrative mechanism. Five of the eight sites offered examples or variations of this pattern. A contrasting mode was one of local or bottom-up implementation, mainly school-based and grass-roots in its organization and decision-making. Metro City and West City Street School exemplified variations of this pattern. One site, Lenape, represented a hybrid: a top-down decision to implement technology, within which local initiatives were encouraged and rewarded. Although each of the sites we visited represented a different point on a continuum from top-down to gross-roots control of the process, each seemed more like one than the other, hence the labels "top-down" and "bottom-up or grass-roots" even though no site exemplified a pure form of either.

The top-down pattern characterized West City CAI, Valencia, Davis County, and the Neptune and Writing to Read installations in East City. Common to all of these sites, at least at the time of implementation, was strong, centralized leadership; four of the technology sites were located in two major cities. Common as well were centralized, skills-based curricula to which the technology (except in the case of Writing to Read) was or could easily be tied. And common to all was a choice or adaptation of technology that was consistent with the objectives-based curriculum.

In the two instances of grass-roots implementation, Street School and the Metro City Technology School, there were two quite different examples of building-level activity, with some common features. In the case of the former, the technology was introduced from outside the school, with the intention of involving teachers actively in developing new uses for it. Over time, the diffuse and discipline-based organization that characterizes high schools seemed to have undermined continuing support of the technology in the absence of strong building leadership favoring it. When the core group of five trained teachers dissipated, and the principal who had originally supported the school's participation in the original project was replaced with another, inertia and the press of other priorities diminished the technology initiative. At the Technology School, a much smaller entity, a core of interested staff remained committed to a set of shared goals into which the use of technology could be integrated. The Technology School curriculum was created, within the overall outline provided by the city and state, at the building level and by the faculty acting as a body. The uses of technology were, therefore, ratified (if not participated in) by the total faculty.

Lenape was an interesting case of an amalgam of the two patterns. A decision by the superintendent to make the district a pioneering one in the use of technology was made operational by the creation of a district-level technology coordinating function. Even before the arrival of the curriculum coordinator, there was enthusiasm for this decision at the high-school level and there followed a deliberate attempt on the part of the technology coordinator to create building-level initiatives and support for technology at the elementary and junior high schools. As a result, a wide variety of activities were under way; different buildings demonstrated different levels of interest in technology; and the coordinator appeared to be running a three-ring circus. (He did not seem to mind.)

As noted in the introduction, all of the factors examined in this study were inter-related. For example, elements in the context may have influenced the choice of technology, which, in turn, may have influenced the process through which the innovation was implemented. Our focus on individual features was an expository device, not intended to suggest that factors acted in isolation. In particular, almost all of the topics discussed to this point had some influence on the unfolding of the implementation process. Some of these influences were strong and direct, some were indirect and subtle, some were unexplained by the limited information gathered in this study.

Two of the features mentioned previously were closely associated with the pattern of implementation (top-down v. bottom-up): curriculum match and size of the installation. These associations will be examined in the following two sections.

Curriculum match. In all but one of the top-down initiatives, the technology was directly related to an existing or newly developed curriculum, typically skills-based. Although the adopting districts and/or the companies responsible for the systems may have made modifications to meet one another's needs/specifications, a good match between the system and district curricula existed from the outset. In fact, the perceived match was often the main reason for a district to adopt a particular system, or for a system manufacturer to market its wares in a particular district. Such circumstances marked the Neptune system in East City, NUTEC in Valencia, CAI in West City and the assessment and reporting system in Davis County.

With respect to Writing to Read, initial resistance on the part of teachers was related to a perceived lack of fit or conflict with existing curricular goals. Only when some minor modifications were made to the use of the program did teachers relax their opposition. Moreover, what finally won teachers over was their observation that the new methods actually promoted existing curricular objectives.

In the three "bottom-up" sites, the technology was less central, more eclectic, and intended to serve the curriculum in ways that would evolve. At Street School and in Lenape, the major goal of technology use was to encourage teachers to adopt and develop applications in the service of the subjects they taught. In Metro City, the goals were initially quite diffuse. At the outset, teachers accepted the LOGO notion that students could use the LOGO language to explore important ideas that transcend specific curricula. When the reality failed to match the intention, the teaching of LOGO became the curriculum, or at least part of it. In time, teachers began to use LOGO in more directed fashion, in ways that fit with their own objectives; and adopted other applications, most commonly word processing and desktop publishing, as they perceived there to be a need. Two teachers -- one a science teacher and one a math teacher -- continued to work with LOGO to develop applications within their subjects that made use of the unique properties of the language, while the entire staff worked to devise a school-wide curriculum that served its larger goals for the students. Into this curriculum, various uses of the computers were introduced and integrated on a teacher-by-teacher basis.

Size of the installation. The sheer size of the installation seemed to make a difference in the nature of implementation process that occurred at each site. A more top-down style of implementation characterized the larger installations that required considerable initial expense and re-organization (of buildings and of instruction). The process occurred in quite similar fashion, at least from the perspective of the individual schools we visited, in large cities (CAI in West City, the Neptune system and Writing to Read in East City), medium-sized suburban districts (Davis County), and small districts (Valencia). This suggests that the relative size and expense of the innovation, rather than size of district, was the feature associated with top-down implementation.

However, district size was also a factor in implementing these programs, particularly in terms of the ability to maintain district-wide control over a centralized system. Building-to-building variations in the use of district-sponsored technology seemed greater in West City (large) and Davis County (medium) than in Valencia (small). In East City, where the area Chapter 1 administration was responsible for arranging our visit to the Neptune system, we saw a high degree of consistency in the two schools visited; how much variation might have been present in a larger sampling of schools is impossible to say, but the area organization, a subdivision of the larger district into four administrative units, appeared to have created a high degree of central control over school-level functioning within Chapter 1.

A grass-roots, bottom-up, pattern of implementation was observed only in smaller installations in smaller districts. The Metro City Computer School served 150 students, employed nine teachers, and was a model of site-based management. Street School (Lenape) was part of a program that intended to encourage school-based initiatives in the use of technology. Lenape was one of the smallest districts in the study.

External factors

This category includes factors outside the school system, including influences from the community, from business, from the government, etc. Although literature suggests that these factors may be influential in the implementation of change, few of these factors were mentioned in the sites we visited. This is not to suggest that external factors are unimportant. It is instead the case that they did not emerge as salient issues in the technological changes we investigated. Whether this is coincidence or common to educational technology is difficult to say.

School Board

The support of the school board may be essential to major investments in technology and/or the success of specific efforts to change schools. In the smaller districts (Valencia, Lenape) the attitude of the school board appeared to affect the implementation of technology, at least in the minds of administrators. Valencia and Lenape offer positive examples of the support of school boards as important elements in their success in implementing technology broadly in the district; Metro City offers a negative example in that the very existence of the Technology School was threatened as other issues became priorities for the district board.

Other Sponsorship and Partnerships

Donations and other support from outside organizations often provide the impetus for schools' and/or districts' initial experiments with technology. When the seed money or sponsorship is gone, it is not uncommon for changes to take place in the ways in which the technology is used. External sponsorship and philanthropy were responsible for the initial implementation of technology in several of the sites (Metro City, Street School). Several of the sites had continuing connections with organizations and institutions beyond the school and district (Valencia, Lenape). In the cases of initial sponsorship, as in Street School and Metro City, the end of the period of external support signaled a change in technology use. In Street School, computers were reassigned and used in a more limited set of applications; in Metro City, the teachers assumed responsibility for determining how the technology would be used, but only after a period of initial paralysis. By way of contrast, the sites with ongoing support (from the state in the case of Valencia, and from the state and local businesses, in the case of Lenape) were able to diversify their technology equipment and the uses thereof. There were very few existing relationships between schools and external businesses and industries prior to the introduction of technology, but a number were developed as a result of its use, and they had positive effects on implementation.

DISCUSSION

Common Clusters of Variables

Although it had not been our intention to seek out similar projects -- on the contrary we sought to identify projects that differed in terms of technological applications and implementation -- we found two distinct patterns of technology use and implementation in the sites we visited. The circumstances were not identical in every case but the patterns of events were similar enough to our own and others' experiences outside of this study to suggest that these two configurations of technology implementation occur with regularity, and the relationships noted in these sites may have wider applicability. As prototypes they may be useful to help districts reflect on their own efforts and avoid pitfalls that have befallen other users in similar situations.

Top-down, curriculum-reinforcing CAI

The first model of technology implementation is characterized by the top-down implementation of technology in a comprehensive instructional role, e.g., a CAI system. The prototype of this approach in the present study was the Valencia district, but similar patterns were observed in East City and West City. The elements that characterized the approach were a strong, centralized decision-making process leading to the adoption of the technology, the use of technology in a major instructional role across one or more broad curriculum areas, the isolation of classroom teachers from the operation of technology through the use of technicians, the continuing use of the application over several years, continuing administrative support and rewards for use, limited use of printed data on student achievement produced by the system, gradual realignment between the content of the application and the regular curriculum as misfits were detected, and the adoption of mechanisms to enhance communication about student performance to teachers.

Though we will not comment at length on all of these conditions, some seem worthy of elaboration. First, it should be noted that the major difference between the application of technology in the three sites that fit this general model was the range of students served by the system. In one instance the CAI system provided instruction in reading and mathematics for all students in the school. In the other two cases the systems were used only for remedial instruction with selected Chapter 1 students. Nevertheless, there were interesting similarities among the three situations.

In all cases there was broad-based support for the implementation of the system within the relevant sectors of the school administration. (Because of the expense associated with networked CAI systems, such support would be a prerequisite for allocating the funds to purchase the equipment and software.) In all cases teachers had not participated in significant ways in the decisions to implement the systems. In the case of programs that served only small numbers of identified students, such as Chapter 1 programs, this was not surprising. However, teachers had only a limited role in the Valencia decision to adopt a CAI system to deliver major portions of the reading and mathematics curriculum to all students.

We thought it noteworthy that the administrators chose to implement these systems in a way that minimized the need for teachers to learn to operate the computers. This may be in part of a function of the systems themselves. They are not designed to require much intervention on the part of instructors. Nevertheless, in all cases a buffer was present to insulate the classroom teachers from the operation of the systems. We suspect this greatly reduced their anxiety about the technology, and it potentially reduced objections they might have had to its introduction. At the same time, it had the effect of offering teachers few opportunities to gain experience and ease with the technology. In this way, the administrators' actions created a kind of self-fulfilling prophecy with regard to teachers' interactions with the technology.

It was also interesting that in all three sites very limited use was found for computer generated monitoring and diagnostic reports of pupil progress. These reports were not widely used by teachers, who did not find the regular reporting of skill scores and performance data to be valuable. This does not necessarily mean that such reports are useless nor that the reporting programs within these systems were poor. There are other explanations for the apparent lack of utility of the printed diagnostic reports. In the case of Valencia, classroom teachers were always present in the laboratory with students and had first hand knowledge of their interaction with the software. For these teachers the computer print-outs were only a secondary and possibly redundant source of information. In the other two schools, the regular classroom teachers had limited motivation for using the printed reports for a slightly different reason. In these situations the teachers were used to sending students to specialists for remedial work and not having to integrate this supplemental instructional program directly into their own lessons. Thus, the computer-generated reports served no direct instructional purpose for the regular classroom teachers. Nevertheless, teachers in all three location also explained that they found the printed reports to be difficult to use, complex, and uninteresting. Yet they contained information that most would agree should be relevant to instructional planning.

The minimal use of printed status reports was offset somewhat by other mechanisms to communicate information about student progress. In Valencia this took the form of requiring that teachers observe students as they worked on the computer. In another site teachers and resource specialists were required to hold "collaboration" meetings in which they shared information about the students' accomplishments in the special remedial program. These alternative communications opportunities suggest that administrators recognized the importance of keeping teachers informed of student progress and took actions to try to enhance the process.

Finally, it should be noted that one of the three sites discontinued the use of the CAI systems after a few years because of dissatisfaction and a change in direction. The biggest factor in this decision was the age and lack of sophistication of the technology. It was clearly "old technology" that had been replaced by much improved versions. Nevertheless, when it was discontinued the schools did not move to newer networked CAI systems, but chose instead to be shift their focus to microcomputers. This decision was made primarily at the district level.

Grass-roots, curriculum-challenging individual applications

A second approach that we saw in multiple sites was the adoption of teacher-selected applications of individual pieces of software to address bits of the curriculum and/or provide enrichment. Lenape was the prototype for this approach, but similar observations were made in West City Street School and in Metro City.

While in all cases the initial impetus for the activity came from the administration or from outside the school system -- a federal research project, a corporate donation -- the main vehicle of implementation was the individual teacher. Each teacher had to learn to use the technology and determine how to integrate it into his or her instructional program.

This approach was characterized by the use of microcomputers in labs or classroom clusters; the need for extensive initial teacher training and continuing staff development over time; wide diversity in the use of applications software within broad general objectives; greater teacher choice in the adoption and use of the technology; the emergence of technology "champions" among teachers and administrators, and strong dependence on these; experimentation with and initiatives for new applications emerging from teachers as well as administrators; variability among sites in the extent of participation based on the level of administrative support; a negative impact of turnover in key staff (innovators and technology champions); changes in focus over time; ideas flowing up the organization as well as down; and continuing (often unanticipated) demands on resources for equipment and support.

The three sites that inspired this model were at different stages in their implementation processes -- in one district the technology initiatives were only in their second year, in the other two they were at least four years old -- so there is more variation in our description. All three opted to use microcomputers and application-specific software to promote greater technology use. These projects had broader, less-specific goals than the CAI projects in the first cluster. The basic difference was that the power to operate the computers and determine how they were to be used was put into the hands of teachers and students. Though they did not label their activities in this manner, all three were experimenting with the use of technology to see what impact it might have.

On the surface this appeared to be a more "democratic" use of technology. Certainly, more control is given to teachers and students. Yet, it is interesting to note that the administrators continue to play a key role in the continuing use of the technology. Administrative support and encouragement were significant factors in promoting technology use in these sites. Unsupportive administrators squelched fledgling technology initiatives through lack of encouragement (whether intended or unintended). In this respect teacher-based initiatives appeared to be very fragile; they needed continuing nurturance, encouragement, and support. Certainly, ongoing staff development was a crucial factor, and funds for such activities were controlled by the administrators. Thus, even in these teacher-focused initiatives, the role of the administration was key.

The bottom-up initiatives relied heavily on the presence of technology champions or gurus, who could share their enthusiasm and expertise with their colleagues. In the three sites such technology experts emerged from the ranks of teachers or were recruited to act in leadership positions vis a vis technology. Interestingly enough, the initial champions were not very successful in replicating themselves. We did not see evidence of a second generation of technology gurus emerging. The number of users was increasing, and to some extent their reliance on a few key experts was diminishing, but new experts did not seem to be emerging. It was as if a small percentage of the staff had the inclination/potential/personality to become leaders in the area of technology and they rose to the fore in the first wave of enthusiasm. Those who followed often became effective users of the innovation, but not leaders.

The lack of a second generation of technology champions became a problem because many of the initial leaders left the system after a few years. We cannot say whether this was coincidental or whether it is a predictable consequence of empowering certain dynamic teachers with new skills. (Others have reported on the phenomenon of technologically sophisticated teachers leaving the teaching ranks.) Whatever the case, loss of key staff may occur, and it may have surprisingly detrimental effects on grass-roots technology initiatives.

In the more mature sites there was a tendency for technology use to narrow over time and for the number of active technology-using teachers to decline. Both "older" programs had evolved from diverse, grass-roots highly-individualized applications into more structured, course- and discipline-specific technology use. For example, in one district the computer laboratory that had been shared by teachers from four or five different departments was now used by the business education department for typing and correspondence classes more than three-quarters of the time. The other teachers had stopped bringing classes to the facility. Part of the reasons for this narrowing in focus was the failure of many teachers to find software to suit their subject area. Part was due to dwindling support provided by a new school principal and decreased peer encouragement as two of the five "core" teachers took jobs in the district central office and one retired.

<u>Methodological questions raised by the study</u>

As has been amply documented during the course of this report, the implementation of technology is a complex process that can be studied in different ways. The present study attempted to incorporate the best of both a large-scale survey of many programs and intensive case studies of single programs. Because the study offered a single, cross-sectional examination of each site, much of the process of implementation was not captured. Instead, implementation was reconstructed from documents and from the memories of individuals with different degrees of closeness to the events of the past.

Needless to say, such an approach is inadequate to the task of characterizing a complex process that takes place over a number of years.

At the same time, the study succeeded to the extent that it identified questions that may form the basis for future studies, and illuminated methodological issues that confront efforts to understand implementation. The findings from the eight sites suggested patterns of implementation that might be examined in more systematic fashion by future researchers. The study also brought into clear view the methodological shortcomings of a cross-sectional approach to investigating process. Finally, the study documented once again the lack of consensus about what constitutes success in the use of educational technology, and the dearth of studies that even attempt to define and measure effectiveness.

Perhaps the most difficult question raised by the study was what **is** implementation? At the start of our investigation we adopted a definition of implementation derived from Fullan (1984) that viewed implementation as the process of putting into practice an idea or program that is new to those expected to carry out the idea or practice. Although the definition seemed simple enough, it was difficult to identify implementation in practice. There were ambiguities about when the process started (with the initial training of teachers? the initial installation of the technology? even earlier?) and when the process ended (when the new practice has been "accepted?" when everyone is using it, with whatever degree of enthusiasm or success? when some specified degree of success has been achieved?). This led to problems deciding which activities should be included under the umbrella of implementation. There were also problems following an implementation process that changed direction; how much is it possible to vary the vision of the original developer or introducer of a given innovation and still be considered implementation of the innovation in question? This study did not answer the question; it simply reinforced its importance.

The investigation also raised the question of how implementation is best studied. From the first, it became clear to us that the cross-sectional approach we adopted had limitations. The traditional input-output models of evaluation are inadequate to the task of describing interactive changes that occur over extended periods of time. Cross-sectional case-studies can examine interrelationships among variables at particular points in time, but they are not sensitive to processes that change over time.

CONCLUSIONS

It seems clear (and almost too obvious to state) that implementation is complex, and its study demands flexibility and complexity in methodology. It would appear that studies of the full range of implementation scenarios requires multiple approaches, including broad surveys, careful case studies of individual innovations, and studies of planned variations of particular innovations, all conducted longitudinally. Moreover, it would appear that the goal of learning about the _process_ of implementation, as opposed to learning about the implementation of a given innovation, might be best served by coordination among researchers doing roughly similar sorts of studies across a range of innovations and/or implementation scenarios.

Directions for future research

Evaluations of new technological initiatives

There is a pressing need for studies of the effectiveness of specific technologies in different types of settings. Too often, studies of the effectiveness of technology are conducted by the developers or marketers of the hardware or software. There is a need for dispassionate studies that examine the impact of the technology operating in different settings on different types of students.

Another shortage in the area of evaluation is of studies that examine technology in comparison with other instructional modes, to address the concerns expressed by many of the people we interviewed: whether expenditures for technology are justified by improvements in the efficiency or effectiveness of instruction.

Classroom and/or teacher-level studies

As noted above, the study described here focused on schools or districts. While there are important variables related to the nature and success of implementation that must be examined at the level of the school and/or district, it is also the case that important variations exist at the level of individual teachers and/or classrooms. The relative importance of school- and classroom-level variables can only be assessed by studying implementation in several classrooms in the same school. Such studies should enable researchers to examine the interaction between individual teachers and the larger context of the school and or district.

Some of the same questions that were asked of schools can be asked of classrooms. These include the nature of the technology application and its relation to the curriculum; the organization of the classroom and the changes required by the technology; the influence of the teacher's orientation and attitude on the use of the technology; the training and continuing support provided the teacher; and the uses and effects of the technology for different types of students within the classroom.

Broad-based surveys

Case studies and small-scale research always raise questions of generality. How typical were the sites we visited of conditions in other schools, other districts? A logical next step would be to take some of the questions raised by the case studies and seek answers from a broader, more representative group of schools. The value of surveys is that they can provide information about the frequency of the events described here and about the extent to which the patterns we discovered are shared by large numbers of sites.

Some of the questions that might be addressed by such surveys include the frequency with which implementation occurs in top-down or bottom-up fashion and the extent to which the relationship between a particular application and the mode of implementation is constant; the frequency of occurrence of specific configurations of technology (integrated systems, for example) given particular curricular emphases (e.g., skills-based curricula); the relative longevity of different applications and the relationship between longevity and some of the factors examined here; and the patterns of use that exist given different amounts of time since initial implementation. There are undoubtedly other questions of at least equal interest that are amenable to a broader study with a more limited focus.

More controlled studies

At the same time, there are questions that are most appropriately considered in the context of studies that attempt to control some of the variation that plagues studies based on naturalistic observation. These studies would be conducted under quasi-experimental conditions and would require the use of comparison groups. Within-school studies in which alternative technologies are applied to a common curriculum would help to answer some of the questions of effectiveness that continue to plague researchers in educational technology. Similar designs could be applied to questions related to differences among teachers in attitudes toward and preparation for the use of technology.

Implications for Developing Technology-Based Assessment Systems

These eight case studies provided some interesting insights into the use of technology for the purposes of assessment. While only one of the eight sites was using a computer system that was specifically designed for the purposes of testing or assessment, many of the applications in use in the other districts had assessment components. Furthermore, some of the non-assessment conclusions we drew have assessment-related corollaries that will be discussed here. These question are particularly important for anyone who is considering the development of technology-based assessment systems.

Lack of Perceived Value

One major conclusion we draw from this study is that teachers find little use for the information provided by existing computer-based student assessment components. Moreover, they show little enthusiasm for using computers to "fine tune" the testing and assessment process they currently employ. These conclusions were based on observations of large-scale integrated computer systems with broad, comprehensive content coverage, i.e., CAI systems. The microcomputer-based projects we visited generally lacked any meaningful assessment components and the situation regarding assessment feedback was worse.

There were many reasons for the observed lack of use of assessment information. The first reason was that the information provided by existing systems was not organized in the same way the curriculum was organized. The categories or skill clusters in the printouts did not exactly match the content organization used by the teachers, and teachers did not seem to be willing to put in the effort to translate from one content scheme to the other. (The exception to this was the district that had a skills-based curriculum that matched or could be easily matched to the skill configuration inherent in their computer-based system.)

The second reason for the lack of use of detailed, computer-generated, student performance information was that these data were not meaningful for instructional decision-making. Despite the fact that the information provided by these systems was relevant to student progress, many teachers did not use it. We suspect that many teachers are not accustomed to micro-managing their instructional programs to this degree. They may base decisions on more general impressions of performance, and may not have fine-grained instructional alternatives that would be responsive to skill by skill data.

The third reason was that the printouts and displays were confusing, complex and difficult to understand. This was a situation that could be remedied fairly easily. In fact, some of the vendors had made improvements in their printouts after receiving feedback from users.

There were two other reasons for low use of the computerized testing system in one district. First, many teachers were unwilling to learn to operate the technology. Second, many found that it required more effort to do the same testing by computer than to do it in the traditional paper-and-pencil fashion. The system provided no rewards or incentives that were strong enough for teachers to put in the effort required to use the technology regularly.

The one exception to this gloomy picture was in the area of reporting. Teachers did seem to value the ability of the computer to generate individual student reports for parents. This was particularly important in districts with skill-based reporting requirements. However, in such situations it was crucial that the reports matched the district's skills continuum exactly. Even here, teachers waited until the last minute, recorded skill mastery decisions by hand and entered them into the computer for reporting purposes, rather than using the testing system to develop, score and record mastery tests.

If these are, in fact, the major reasons for the observed lack of use, it suggests that other computer-based systems are likely to encounter the same resistance. Most of the constraints described are inherent in the school setting, and cannot be overcome by improvements in design. The implication seems to be that a system designed merely to supplement the existing repertoire of teachers' assessment techniques has an uphill battle. To make a significant impact on teachers' use of assessment information a system will have to embody a new way of thinking about teaching and assessment. However, the developers of such a system will face the monumental task of re-educating teachers.

Fear of Technology

A second conclusion we drew from the case studies was that many teachers still resist using technology. This reluctance is strong enough that almost half of the districts we visited developed mechanisms to insulate the teachers from the operation of the computers. This was true even in the case of one microcomputer-based reading program (Writing To Read) in which teachers only had to load floppy disks at the beginning of each instructional session. Such mechanisms often serve to perpetuate the separation of teachers from technology by limiting the opportunities for teachers to learn and become comfortable with the applications.

The bottom-up individualized projects faced similar obstacles. In these instances a concerted effort was made to have all teachers to be technology users. The effort typically involved extensive staff development, consistent encouragement and support, changes in reward structures, and even some cajoling and threatening. Even with all these pressure aligned in favor of technology use, many teachers were reluctant, and some were outright resistant. Furthermore, over time the number of technology users declined as the initial focused pressure decreased. This bodes poorly for a system that will require individual teacher operation.

Fit With Curriculum

Possibly the most important variable in teachers' use of technology-based systems, either networked CAI or stand alone microcomputers, was the degree to which the specific application could be integrated into the existing curriculum. While this variable relates most directly to content-based software, it also directs implications for assessment systems. To maximize potential use and potential benefit, computer-based assessment must also fit with existing curriculum.

Continuing Administrative Support and Staff Development

The introduction of computers for instructional, enrichment, or assessment purposes represents a significant change in the way teachers perform their jobs. It is not easy to bring about changes in the core operation of schools (or other organizations). The sites we visited were successful in modifying the way students were taught in the direction of greater technology use only through consistent pressure, encouragement and support. These factors will be critical in the acceptance of any new computerized assessment and mastery systems. However, they are difficult to control from outside the school system and, as a result, pose significant obstacles to the implementation and institutionalization of new forms of operation. Developers of such systems will need to incorporate an introduction and implementation model that maximizes administrative support, recognizes the scope of the staff development effort that will be required, provides for continuing contact and encourages continuing support from administrators over the life of the program.

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TABLE 1

Selection Criteria and Initial Implementation Facts

Site	Curriculum Application	Hardware Configuration	Year of Implementation	Unit of Implementation	Degree of Continuation/ Expansion
West City Street High School	Productivity tools Many curriculum areas	Stand-alone microcomputers	1983	School*	High
West City CAI	CAI in Reading and Mathematics (Ch. 1)	Minicomputer networks	1976** 1977-80**	Group of four schools** Individual schools	Low
Valencia	CAI in Reading, Mathematics and Language Arts	Minicomputer networks	1983	District	High
Davis Co.	Assessment and resources system	Minicomputer networks	1983	District	Moderate
East City Neptune	CAI in Reading and Mathematics (Ch. 1)	Minicomputer network	1983	Area(sub-district)	Moderate
East City WTR	Beginning Reading (Ch. 1)	Stand-alone microcomputers	1984	Group of schools	High
Lenape	Many applications Many curriculum areas	Stand-alone microcomputers	1984	District	High
Metro City	LOGO	Stand-alone Microcomputers	1983	Mini-school	Moderate

* Implementation was at the school level, but was part of a national demonstration project involving 89 secondary schools and a local network of seven schools with a teacher-training institution.

** Initial implementation occurred in four schools in 1976 as part of a federally-funded research study; later individual schools adopted CAI using their own or district funds

Table 2

Characteristics of Sites

	Unit of Observation	Location	SES of Students	Racial Composition of Student Body
West City Street H.S.	Single school	Major metropolitan area	Middle and upper middle class	Mainly White
West City CAI	Three schools	Major metropolitan area	Low SES	Predominantly Black and Hispanic
Valencia	K-8 district	Small city in Agricultural/ fishing area	Low SES	White, Hispanic, Asian
Davis Co.	District	Suburb of major metropolitan area	Middle and upper middle class	Predominantly White
East City Neptune	Sub-unit of large urban district	Major metropolitan area	Low SES	Predominantly Black
East City W2R	Sub-unit of large urban district	Major metropolitan area	Low SES	Asian, Black, White in approximately equal proportion
Lenape	K-12 district	Small city	Lower middle class	White
Metro City	Single school	Major metropolitan area	Low SES	Mainly Black and Hispanic

Table 3

Observed Technology Applications

Site	Principal Application	Secondary Application
West City Street School (High School)	Multi-disciplinary set of general-purpose software tools	Office training, programming, computer literacy, subject-specific software, teacher applications, office administrative functions
West City CAI (Elementary and Junior High)	Computer assisted instruction in basic skills	Computer literacy, intro programming in some locations
Valencia (Elementary and Middle School)	Computer assisted instruction in reading language arts and mathematics	Specialized, multi-technology science room computer-based reading social studies videodiscs, miscellaneous software used by some teachers
Davis Co. (Elementary)	Network-based assessment and instructional resources information system	Introduction to computing, miscellaneous software, programming in some schools
East City Neptune (Elementary)	Computer assisted instruction in basic skills for selected Chapter 1 students	Central office administrative computer, microcomputer lab to be installed in near future
East City WTR (Elementary)	Multi-media introduction to reading program	Microcomputer labs with enrichment and remediation software
Lenape (Elementary Junior High and High School)	Exploration of curriculum-related software in many subjects, with focus on higher-order thinking	Programming, instructional television
Metro City (Junior High School)	Programming with LOGO in a variety of subjects	

APPENDIX A

Interview Protocols and Observation Checklists

Interview Questions for Computer Context Study

Questions for Teachers

Adoption

Were you involved in the initial decision to buy/lease/use computers in the school?

Do you think it was a good decision? Why or why not?

Do you know how it came about? Can you describe what happened?

What were the original goals for the computers? How, if at all, have they changed?

Implementation

How did people prepare to use the computers?

How much training did you receive? What was the focus of the training? How long did it last?

Who conducted the training? Where was the training carried out?

Did the training meet all your needs? Were you ready to use the machines by the end of training? Did you learn all you needed to know?

What were the strengths of the training? What was missing from the training?

Did you receive any rewards or incentives for learning to use the computers?

Were administrators involved in the training or preparation for using the computers?

If you could change anything about the preparation, what would you change?

Is preparing for computers different than preparing for other educational changes, like new textbooks or teaching approaches? In what ways is it different?

Did you have to make major changes in the way you planned your lessons, taught your classes or organized your schedule? Could you describe them?

Sustained Use

What is the extent of your use of computers now? (What was the extent of your use of the computers when the system was still here)?

What do (did) you use them for?

Did this replace instruction you were doing before the computers arrived?

What changes have there been (were there) in the curriculum as a result of the computers? Which subjects/topics received more attention, which less?

What changes have there been in your teaching as a result of the computers? What lessons do you teach differently? In what ways?

How is (was) student work on computers integrated/coordinated with their classroom work?

Who coordinates (coordinated) the use of the computers? How is (was) scheduling handled? Which students use the machines? Which teachers use them? Can you get access when you want it?

Is there a coordinator or resource person who manages the computers or monitors the students? What does this person do? How important is this person to the functioning of the program?

Does (did) the system provide you with information about individual students' progress? What kind of information? What do (did) you do with the information? Is (was) it useful? Why or why not?

What do (did) you do when you have (had) questions about the computers or the software? Hardware and maintenance questions? Teaching and application questions?

In what ways do (did) you receive support related to the computers from the district? The principal?

What kinds of support do (did) you rely on for your use of the computers? What do (did) you need that you are (were) not getting?

<u>Changes</u>

Have there been any changes in school policy or district policy that affected the use of the computers, e.g., changes in allocation of resource personnel, changes in the goals of computer education? Please describe the changes.

Do you think the computers will continue to be used as they are now? Why or why not? What changes would you like to see? What changes do you anticipate?

Who will make decisions about future use of computers?

If you could make change to the system, how it was introduced, or how it is used in the school, how would you change it?

Do you think other teachers would want the same changes?

<u>Overall</u>

What kinds of problems have you had with computers? Are these problems similar to or different from those that you may have had with other educational changes, like new textbooks or instructional methods?

What kinds of successes have you had with computers? Are these successes similar to or different from those that you may have had with other educational changes, like new textbooks or instructional methods?

How do you think your assessment of the computers compare with that of other teachers? The principal? Students?

What are the important differences between schools that are actively involved in computer use and those that are not?

What has it "cost" you to use the computers, in terms of time, effort, changes, etc.? How much work has been involved?

What "benefits" have you gained from the computers, in terms of opportunities, student outcomes, etc.?

If someone were to offer the schools the chance of participating in a new program with an innovative computer system that has outstanding student materials and provides detailed information about students' strengths and weaknesses, would the school chose to participate? Why or why not? Would you chose to use it with your students? Why or why not?

Is there anything about this school/principal/staff that has affected computer use that might not be present in another school?

Interview Questions for Computer Context Study

Questions for School Administrators and/or Computer Coordinators

Current Uses of Computers

How many computers are there in the school, and of what variety?

Where are they? (Classrooms, a laboratory, administrative offices, etc.)

In what configurations do they exist?

How are the computers used, and by whom?

Who has access to the computers? Who controls their use? Who is "in charge" of them? Who services them?

Who are the users of the computers? (Individual students? Whole classes?) What proportion of the students in the school get to use the computers? How often, on the average, do the users get to use the computers? How is use determined? If not all students use computers, is use governed by student choice? teacher choice? administrative decision? Are the students who use the computer systematically different in any way from students who don't?

What are the various uses of computers in this school/district? How long have these uses been in effect?

Adoption

Were you involved in the initial decision to buy/lease/use computers in the school? If yes, how was this particular configuration/system decided upon?

Do you think it was a good decision? Why or why not?

Do you know how it came about? Can you describe what happened?

What were the original goals for the computers? How, if at all, have they changed?

Implementation

How long has the school had computers, and how long has it been using the system/software/etc. that is now in use?

How much and what kind(s) of training was (were) provided instructional and administrative staff in the use of the machines and/or the system?

What kinds of resistance and/or enthusiasms greeted the introduction of computers? Who are the champions of technology in the school and who are its resistors?

Sustained Use

If there is an integrated system in use, who is "in charge" of it? What roles do various instructional personnel play in the administration of the system? How were these people trained in their roles and how did they become familiar with the system?

What is the general level of technological sophistication among the staff of the school?

What resources, courses, in-service opportunities are available to teachers and other staff to enhance their own computer skills and/or to improve their use of the computer and/or software for instruction?

What are the goals of computer use in the school(s)/district? What evidence exists that the goals are or are not being realized?

How is student work on computers related to/integrated with their classroom work?

How much opportunity is there for elective work with computers in addition to what is mandated? Are computers available to students during lunch, before and/or after school, or during "free" time?

Where do/did funds for the computers and the software come from? How much of the school budget is currently allocated to computers and/or software?

Changes

Have there been any changes in school policy or district policy that affected the use of the computers, e.g., changes in allocation of resource personnel, changes in the goals of computer education? Please describe the changes.

Do you think the computers will continue to be used as they are now? Why or why not? What changes would you like to see? What changes do you anticipate?

Who will make decisions about future use of computers?

If you could make change to the system, how it was introduced, or how it is used in the school, how would you change it?

How would you evaluate the computer set-up that is now in place? What are its strengths? Its shortcomings?

Who will make the decision about whether or not computers will continue to be used as they now are?

For schools/districts that have stopped using a particular system:

> Why do you think the school/district stopped using the system? If there was not a deliberate decision stop using it, how did the change come about?

If a decision was made to stop using it, who made the decision? In what ways did the system fail to fulfill its promise? On what basis was the decision made?

What is taking the place of the system? How are computers now being used, if at all?

Overall

What kinds of problems have you perceived with computers? Are these problems similar to or different from those that you may have observed with other educational changes, like new textbooks or instructional methods?

What kinds of successes have you observed with computers? Are these successes similar to or different from those that you may have observed with other educational changes, like new textbooks or instructional methods?

How do you think your assessment of the computers compare with that of teachers? The principal? Students?

What are the important differences between schools that are actively involved in computer use and those that are not?

What has it "cost" your school (district) to use the computers, in terms of time, effort, changes, etc.? How much work has been involved?

What "benefits" do you perceive have been gained from the computers, in terms of opportunities, student outcomes, etc.?

If someone were to offer the schools the chance of participating in a new program with an innovative computer system that has outstanding student materials and provides detailed information about students' strengths and weaknesses, would the school chose to participate? Why or why not? Would you chose to use it with your students? Why or why not?

Is there anything about this school/principal/staff that has affected computer use that might not be present in another school?

APPENDIX B

Technology Innovation in Eight Sites

Summaries of Technology Innovation in Eight Sites

West City Street School	Level: High School Identified Application: Multi-disciplinary set of general-purpose software tools Other applications: Office training, programming, computer literacy, subject- specific software, teacher applications, central office administrative functions

This school was selected as an example of a successful cross-disciplinary application of microcomputers as general purpose tools. It participated in the first year of the IBM Secondary School Computer Donation program in 1983 (reported in Cline, et. al., 1986), and received a donation of 15 microcomputers, general purpose software (including a word processor, spreadsheet, data base manager, etc.), a modem and telecommunications software. In addition, five staff members participated in a month-long training program at a local university to prepare them to integrate computers into the instructional program; they continued to be part of a network of participating teachers for the next two years.

The emphasis of the IBM-sponsored training was on the application of the computer as a tool across the curriculum rather than on computer-assisted instruction or the use of subject-specific tutorial software. The teachers who participated in the training, in which principals and district administrators were also invited to take part, offered staff development for the rest of the teachers at the school. The program created a technical support network centered at teacher training institutions. The network fostered communication among program participants via telephone, telecomputing, and a project newsletter. One goal of this process was to provide teachers with a range of options for pursuing their own instructional objectives.

Initially, the IBM program was enthusiastically received. In addition to the donated computers, the school found funds to purchase a second set of IBM computers that were used primarily by the business/occupational teachers. Additional IBM computers were located in various administrative and department offices; the district provided a lab of Apple microcomputers that was used primarily for programming classes, but also could be reserved by interested teachers. The drafting class had a computer for CAD training. All high schools in the district had administrative computer systems for scheduling and student record keeping that were linked to the central office mainframe through telephone lines.

The computers spurred other innovations. For example, methods were found to pay teachers to offer classes after school for parents and other community members, and these classes were well attended. Community fund raising efforts enabled the school to buy a second lab of computers.

The five trained teachers became excited, enthusiastic supporters of the innovation who assumed new responsibilities as change agents, training their colleagues and promoting technology use. In turn, other teachers were excited by the innovation. They learned to operate and use the technology with the support of a principal who helped the staff to promote the broad use of the computers.

However, neither the curriculum nor the instruction in the school changed substantially. Many superficial changes were made, such as having students use word processors instead of typewriters to produce reports, but only one or two teachers made significant revisions to their curriculum based on the capabilities of the computers. (For example, the honors health teacher developed a unit on biorhythm that relied heavily on computer software and another computer-based unit on calories and diet.) Perhaps because the computers had to be shared among so many classes, perhaps because teachers were frustrated by the lack of software appropriate for their subject area, over time, the teachers' interest in the computers waned. Many stopped using the lab altogether.

As the majority of the core group left the school through retirement or promotion, the teachers who remained did not sustain the level of excitement and enthusiasm of the initial group. A new principal with different priorities failed to support and encourage technology as it had been supported under the previous leader. Computers continued to be used, but their use was confined to business and programming. A few teachers continued to explore the use of computers on their own according to their own interests but the use became much less widespread than at the height of enthusiasm for the new project.

Thus, by the time of the site visit, the impact of the IBM program had greatly diminished in the four years since its initiation. Computers were not used extensively as tools across disciplines, but had found targeted niches in certain subject areas. For example, use of the IBM computers was concentrated in business department, primarily for office training. A lab of Apple computers was used primarily for programming and computer literacy classes. While there were a number of different software applications being used, these represented isolated instances rather than a consistent strategy. A group of computer using teachers met periodically to share ideas and promote use, but most of those trained during the summer institute had left the school for other jobs or had retired.

The physical structure(s), the computer labs, remained in the school and continued to be used, although not necessarily or exclusively by the original group of teachers, for instruction. At the time of our visit, additional labs had been installed, paid for by other sources: the district, PTA funds, a business program. The bulk of the computer equipment in the school was the province of the business department. This meant that access and scheduling were controlled by the business department and it had become cumbersome for teachers in other departments to work with their students on the computers or to make assignments on computers and expect their students to gain access. A computer curriculum had been implemented (beginning and intermediate programming, mainly), with two teachers to teach it. And, while there were pockets of computer use in other subject areas in the school, there was hardly the range and variety of use across the curriculum that the IBM project had initially envisioned.

<u>West City</u> <u>CAI</u>	Level: Elementary and Junior High Identified Application: Computer assisted instruction in basic skills Other Applications: Computer literacy and introductory programming in some locations

Three schools in a metropolitan district were selected because they had used minicomputer-based CAI systems for two or more years and recently had discontinued their use. The decision to discontinue the use of the systems was based on the district's assessment that they were no longer effective technological applications. Thus, these schools represented unsuccessful applications. (It was somewhat ironic that one of the first studies of the effectiveness of CAI had been conducted in one of the sampled schools. The study found significant improvement among students who completed drill and practice lessons on the computer.) Each school had a minicomputer-based CAI system that provided instruction in basic reading and mathematics. The system also provided some assessment and reporting. Two of the schools offered this instruction on a pull-out basis to identified Chapter 1 students, the other provided the instruction to all students.

In total, 16 schools in this district had used dedicated CAI systems, primarily to provide basic skills instruction to Chapter 1 students. Two years prior to our visit, the district administration began to question the wisdom of expending funds for such systems. They studied the cost and impact of the systems and decided that the district would shift its technological emphasis to microcomputers. The 16 schools were discouraged (though not forbidden) from continuing to maintain the computer equipment or to lease the CAI software. All but one school discontinued their CAI contracts, though some continued to use the systems as long as they remained operational.

Use of the systems had been totally discontinued at two of the schools visited. The third school had found a technician in the district to fix the equipment when it needed repair, so they continued to use the equipment on a limited basis. All three schools had begun to make a transition to microcomputers. At one school the district supplied a laboratory of microcomputers that was being used for computer literacy and elective programming courses. However, few teachers at the school were involved with technology. The other two schools received individual classroom computers for teachers at selected grade levels. One school purchased additional computers so each teacher had a machine in his or her classroom. Teachers at this school were exploring ways to use the technology, with an emphasis on writing. One part-time coordinator provided training, helped to select software, and tried to promote computer use. There was only one computer at the third school, and most teachers had no contact with it or other new technology.

The three sites visited included one that had participated in a federally-funded study of CAI and two that had implemented similar CAI in Chapter I on their own initiative. As part of the research project, which had been designed to assess the effectiveness of a set of CAI curricula for use in compensatory education, computer labs had been established in 1977 in four elementary schools in the district. For the next three-and-a-half years, at least half of the students in each of the schools received regular drill-and-practice instruction using curricula developed by CCC. The curricula included mathematics in grades 1 through 6; reading in grades 3 through 6; and language arts in grades 3 through 6. Even before 1982, when the research project was completed and federal funding for it ended, additional schools in the district adopted CAI, using their own or district funds.

Among the four schools that participated in the research project there had been variation in the degree to which the start-up of instruction was trouble-free. Acceptance of the program in the four schools was also varied, and seems to have been mediated by the dependability of the system once it was installed; the amount of disruption generated by the scheduling of labs in the schools; and teacher resistance to (yet another) pull-out program. Acceptance increased as the initial problems were resolved and as the effectiveness of the instruction was demonstrated to teachers' satisfaction. The four-year research effort produced a series of reports testifying to the success of the labs in enhancing student achievement and motivation. Presumably, the adoption of CAI by other schools in the district was at least partly a function of this initial demonstration of effectiveness.

In all of three of the schools visited, the original format had been for students to visit the labs for periods ranging from 7 to 20 minutes, from two to ten times a week. In some instances, teachers accompanied their students to the labs and stayed there with them; in others, students worked in the labs under the sole direction of the coordinators and their assistants. Coordinators spent full days in the labs and were responsible for setting up the computers each day, establishing the schedules and maintaining them, supervising students in the labs, and keeping a variety of records for the schools and in the service of the research.

The initial labs set up in 1977 were created from whole cloth, representing first-time ventures into technology for all of the schools. The physical requirements of the lab assumed great importance in those initial sites. The coordinators selected and trained to oversee and manage the labs in the research schools were chosen, in part, for their readiness and apparent ability to take on new responsibilities and for their willingness to embrace technology. Little is known about the start-up in other sites (two of which were visited for this study) in which CAI was installed on the schools' own initiatives.

At the two Chapter 1 CAI sites many teachers were affected by the technology, but only indirectly. Students were taken out of class on a regular basis to receive supplemental instruction in math and/or reading from a resource specialist. The resource specialists and their aides were trained to operate and, in some instances maintain, the CAI system. Classroom teachers may have been familiarized with the system when it was first installed, but they did not receive regular training or updates. From the reports of teachers at one school, there was little direct coordination between students' work on the computer (and the homework that was assigned) and their work in their regular class. In this respect the use of the system was "compartmentalized" and not well integrated into the overall instructional program. The roles and responsibilities of classroom teachers changed little as a result of the technology. Teachers mentioned the advantage of working with smaller classes when students went to work on the computers, but only a few students from each classroom were involved. Furthermore, Chapter 1 students had traditionally been pulled from classes for special remedial instruction prior to the advent of the technology, so these patterns had already been established.

At the second school there appeared to have been better coordination between the content of the CAI and the regular classroom lessons. For at least two reasons. First, there seemed to be better communication between resource teacher who supervised the CAI system and the classroom teachers. Second, the whole school was using a common curriculum and a common schedule of instruction. This made it possible to program the CAI lessons to reinforce the skills needed by the existing curriculum. Because there was greater exchange of information between regular teachers and the resource teacher at this school, classroom teachers relied more upon the CAI system for lesson-related remediation, and adjusted their activities accordingly. However, there was still very little change in the duties of most teachers.

The situation was somewhat different at the school that had participated in the federally funded CAI research project. For one thing, all students used the technology. Consequently, the CAI system was a more integral part of the overall instructional program. Each teacher had to adjust scheduling and curriculum to accommodate the computer program. Classes were divided in half, with the two groups alternating between the lab and the classroom. This gave teachers an opportunity to work with smaller groups, but also required them to adjust the instructional program for all students. As a result, the teachers had to make noticeable changes in their activities. Another significant difference between this site and the other two was the degree of support provided. Research funds were used to pay for an overall project coordinator and a laboratory assistant, so there was additional help to operate the computers and to coordinate the CAI lessons with ongoing instruction. Moreover, the teacher chosen as project coordinator was an extremely dynamic individual who was creative, supportive and worked well with the rest of the staff. Finally, the experiment itself created an atmosphere of excitement and enthusiasm far beyond that reported at the other CAI sites. Teachers felt they were participating in an activity of great importance, and they gave extra effort to make it work. To a certain extent they may have been more motivated than teachers at the other two schools to make changes in their duties and activities.

At the time of our visits to the three schools, the structural changes wrought by the introduction of technology were present to different degrees. Vestiges of the original labs were present in two places, absent in one. One had been eclipsed by an Apple lab. In one, the old machinery remained, virtually untouched, in a portable classroom, which seemed a museum of ancient technology. The equipment was mourned by the former coordinator, whose star had clearly faded and who was teaching in a somewhat shabby portable classroom. One of the original schools had become the site of a district magnet computer school, which seemed to have little to do with the host school. In yet another school, the old equipment was host to an instructional program other than the original CAI curriculum, at least in part because some of the original equipment was still functioning.

The new Apple labs brought with them different organizational structures; two of the lab coordinators from early (although not the earliest) installations were clearly being regarded as supernumeraries by their schools, almost as if they, like the equipment, were outdated.

The CAI systems in this site had the capability to generate printed reports summarizing student achievement. In general, these reports were of limited value to teachers. The use of the assessment data was somewhat different in the two sites that used the systems for Chapter 1 students. In one there seemed to have been little communication between teachers and the resource teacher who ran the computer lab. Printed reports did not necessarily relate to classroom lessons and, over time, the reports were shared with teachers less and less frequently. In the second site, all teachers were following the same set of lesson plans, so the curriculum in the lab could be adjusted to support classroom lessons more effectively. Still, teachers had little use for the paper reports generated by the computer. Once the "lock-step" curriculum was abandoned, and the computer and remediation were less directly relevant to class lessons, interest in the printouts appeared to have declined.

Even at the third site visited, where all students used the computer lab, teachers did not make much use of the reports. (The coordinator used the assessment capabilities to demonstrate program effectiveness.) The teachers seemed to respond well to the personal contact they had with the first lab coordinator, and they had an opportunity to see the topics students were learning for themselves. After coordinators changed there was less communication about student performance.

Inquiries into the basis for the decision to abandon CAI in West City produced conflicting stories. Several individuals attributed it to the political forces in the district. Others said that the technology served its purpose but had simply become outdated. There was also allusion in two of the sites to the fact that the link between the CAI curriculum and the classroom curriculum was weak. There did not appear to be additional studies to indicate a lessening of instructional or cost effectiveness. Nor did the decision to discontinue the original CAI configuration appear to have signaled either a decision to abandon technology altogether or a change in the prevailing approach to compensatory education. And the move to Apple labs, insofar as we could ascertain, was not based on anything like the amount of data that supported the introduction of CAI.

The West City CAI experience suggests that, within a given application, implemented district-wide, there may be significant differences in implementation at the school level, based on the ways in which use of the technology is structured and roles and responsibilities of individuals change accordingly.

<u>Valencia</u>	Level: Elementary and Middle School Identified Applications: Computer assisted instruction in reading, language arts and mathematics Other applications: Specialized, multi-technology science classroom, computer-based reading program, social studies videodiscs, miscellaneous microcomputer software used by some teachers

This district was selected because of its extensive use of a dedicated, minicomputer-based CAI system for instruction and assessment in reading, language arts and mathematics. All students spent approximately 25 minutes each day using the NUTEC computer system in a CAI laboratory that had been established in each school. The system was also used to provide instruction for English as a Second Language (ESL) students. In fact, all of the schools in this district were enthusiastic users of the CAI system.

We visited three schools: two elementary and one junior high school. The minicomputer CAI system was not the only technology in use in these schools. At the middle school, three regular classrooms also were connected to the CAI network; each had six terminals that could access the network software. In addition, a unique, multi-technology, science laboratory had been constructed. It contained individual student work-stations with access to computer software, and videotape and videodisc programming. The customized software that connected the work-stations permitted individualized instruction, monitoring, assessment, and reporting. The school also had a small number of microcomputers that were used by teachers on an individual basis. The school had purchased a videodisc player and an extensive library of videodiscs. One teacher had been released from a portion of his instructional duties to develop social studies curriculum that made use of the videodiscs.

Every student in the upper grades in the elementary schools used the CAI laboratory on a daily basis. In addition, one school had a special classroom dedicated to a computer-based beginning reading program for kindergarten and first grade students and for ESL students. There were also microcomputers in some classes.

The NUTEC system in the Valencia district was first installed in 1983, but it had been preceded by a district-developed computer management system first used in 1979-80 that operated on an early generation of computers. The administration was frustrated by the limitations of the system and the lack of good available software. Working from the vision of their associate superintendent and creative fundraising and judicious money management by a (then) new superintendent, the district installed four NUTEC labs in 1983. (The initial NUTEC installation was paid for with Chapter 1 monies). Additional labs were installed in subsequent years, so that each of the nine elementary schools had one lab and the middle school had two by the time of our visit in 1988.

The NUTEC system was an important piece of an overall plan by the administration to improve achievement in the district through the use of technology. The success of the district in implementing the plan was attributed to a supportive board and supportive parents. The expressed philosophy of the superintendent is that "change must be dictated from outside of the system" and "from the top;" the rest, he maintains, follows. His commitment to achieving the goals he developed for the district included moving administrators around for maximum support of the innovations.

A booster and supporter of technology, he claimed to have met considerable resistance to many of his initiatives from what he terms "a militant [teachers'] union in an adversarial stance." At times he deliberately left the teacher association out of the review cycle in reaching decisions about changes in the schools.

The choice and use of NUTEC followed the adoption of a district-wide, objectives-based curriculum and was closely tied to that curriculum. In the administration's larger scheme, NUTEC served from the beginning to provide practice, review and reinforcement of skills taught in the classroom as well as remediation and enrichment. One of the attractions of the system to the administration was its capacity for providing detailed records and for tracking student progress toward specified objectives.

With the introduction of the NUTEC system a new position was created, that of Laboratory Coordinator, and an individual -- Donna Thompson, not a teacher by training, but a former PTA president and resource aid in the schools -- was hired to fill the position. She was provided with 40 hours of training by NUTEC and quickly became a key figure in the district (she had one office at the middle school, where there were three NUTEC labs, and one at the district office). Thompson managed the overall operation of the NUTEC system. She was responsible for keeping the hardware running (there was, from the start, a maintenance contract), supervising the technicians who actually ran the labs (a staff of 33 at the time of the site visit), and providing staff inservice. And according to a conscious decision by the administration, all teachers visited the labs with their students. In the initial year, according to Thompson, only the classes of teachers who expressed interest in having their students visit the labs had been scheduled there.

In addition to NUTEC, the district introduced the Writing to Read program in several of its elementary schools. It also supported the development of a "smart classroom" in science, an architect-designed technology-rich classroom that includes, among other things, a robotics center, terminals recessed in desks to improve whole-class management, and a complete videodisc system (that uses Laserworks) with a large-screen projection device. Under development at the time of the site visit was a smart classroom in social studies. And plans were in the works for a "smart school."

The Valencia situation was a good example of the implementation of technology as part of a larger vision of instruction. The initial NUTEC installation fit into a previously established curriculum. Additional elements continued to be added and integrated into a larger instructional mission, and technologies were carefully tailored to fit district goals. The Valencia situation was also a good example of a top-down mode of implementation. Major decisions were made by the superintendent and his staff; building administrators were appointed for their support of the district objectives and their willingness to administer in similar, top-down fashion. Teachers were invited to participate in the decision-making and/or development processes to the extent that their own views and goals were consonant with those of the administration.

Like the two sites just described, the major computer activity at Valencia took place in a series of computer labs, eleven in all, located in schools throughout the district. Each upper elementary and middle school teacher had to adjust his or her lessons to accommodate the system. The requirement that classroom teachers visit the labs with their students provided teachers with the opportunity to observe their students learning independently. The administrators believed that this was a powerful tool for changing the way teachers conceptualized their role and organized their interactions with students. While we did not obtain any evidence of such fundamental changes in the way teachers thought about their duties and responsibilities, we talked to teachers who did use the lab time to monitor students' work and offer individual tutoring.

The program was thriving when we visited it; new labs had been added almost every year since the initial installation. The newer labs had a different arrangement from the original ones which made it easier for teachers, to observe and help individual students.

Several classroom teachers had become devotees of the system, and were asking for computers in their classrooms, both to provide their students with extra time on the computers and to make use of the word-processing function that was available. Two teachers were working with such arrangements, but communication with the lab manager was proving inconvenient because of the distance of the classroom terminals from the minicomputer in the lab that controlled individual students' lessons. (To get particular lessons downloaded to the classroom terminals, the classroom teacher had to dispatch a messenger to the computer lab. This could create a considerable delay between sending a student to the computer and having the student actually start work there.) The teachers involved were campaigning for stand-alone micros in the classrooms. At least one teacher was weighing her desire to have access to the entire NUTEC system in her classroom against the benefit of having control over the machines there.

Because the district had made technology a priority, a small group of teachers evolved among those who, like the science and social studies teachers involved in the development of the smart classrooms, expressed interest in and willingness to experiment with technology. Both of these teachers had been provided with release time, support for training, and seeming <u>carte blanche</u> to cultivate their ideas. The superintendent expressed his willingness to support others in similar fashion.

The NUTEC system was marketed with its own set of evaluation data, derived from selected sites in which the system has been installed. In addition, the system generates an extensive series of reports on every aspect of student performance and includes, as well, the capacity for administering questionnaires to students, teachers and administrators, and formatting the results into a family of reports. The system administrator at Valencia claimed to have data that demonstrated the effectiveness of the system in improving average student achievement and enhancing student motivation in the district, although the improvement occurred primarily in students who were already above the median.

District administrators expressed their satisfaction with the system by citing improved standardized test scores. The gains in standardized test scores were not achieved immediately following the introduction of the NUTEC system. Rather, it took several years for the improvements to manifest themselves, presumably after teachers had grown accustomed to the system and started to work on the district-wide curriculum objectives to which the system was keyed. To be sure, the introduction of the system coincided with other changes in at least two of the schools visited: new administrators, new rules for student conduct in the junior high school, and the introduction of a number of technology initiatives including Writing to Read in the elementary schools. Moreover, since our attention was directed to the technology in the district, we may have missed changes in the district apart from the technology. For example, the superintendent had arrived five years earlier, around the same time as the first NUTEC installation.

No evaluation of outcomes had been attempted in the case of the smart classroom, perhaps because the desired outcomes had not been clearly defined. At the same time, there seemed to exist, at least among key administrators (the superintendent, associate superintendent, and two building principals) a general belief that the introduction of technology was itself a desirable outcome. Their reasons were a shared conviction that technology can achieve more efficient, more individualized and richer instruction, although they had no evidence that this was the case. Thus, the existence and acceptance of the various technologies, plans for new technological applications, and the expression of interest on the part of teachers in exploring new applications seemed to represent desired outcomes for the administration. Administrators interviewed pointed with considerable pride to the visible innovations: the NUTEC labs, the smart classroom, the teacher who was working on a videodisc project for junior high school social studies, and the plans for future innovations.

The district's heavy investment in technology had garnered considerable publicity for it across the state. The district had commissioned the preparation of a professional videotape describing the smart classroom and plans for the smart school. At least one projected use for the tape was attract new sources of funding for the technology initiative, another positive outcome from the administration's perspective.

Davis Co	Level: Elementary
	Identified Application: Network-based assessment and instructional resources information system
	Other applications: Introduction to computing, miscellaneous software, and some programming.

This site was selected because it used an extensive computer-based student assessment and instructional resources system. The district was included in the study as a successful example of the application of technology to assessment. The district information system had been developed by the company according to specifications the district provided that were related to its skills-based curriculum in grades K-8. The system software operated on a computer in the district office to which each elementary and middle school was connected through a network that involved a scanner and terminal in each school. The system was used in all elementary schools for monitoring attainment of individual student objectives and reporting to parents. Teachers could also use it for customized classroom assessment and as a source of information regarding curriculum and materials.

The information system had been introduced six years prior to our visit. It was installed, following a period of comparison shopping by the district, in the service of the district-wide objectives-based curriculum for which teachers were accountable to parents, the administration, and the board. When the curriculum was developed and introduced, it became clear that the record-keeping and reporting were onerous chores that might well be assumed by computers; the district then sought a system to match its needs. In addition to its recording and reporting components, the system also provided a test-item bank in which each item was keyed to requisite skills. Teachers could develop customized tests to cover curriculum units, or they could use predefined tests that were coded to match groups of skills in the normal sequence of instruction.

Teachers could also add their own test items to those in the bank to produce tailor-made tests for their own use. In this respect, the system was extremely flexible. The process of requesting or generating a test took place on-line. The teacher or aide logged onto the system at the school's terminal, and communicated with the mainframe computer over a telecommunications network. Items could be reviewed, selected or added interactively and, once a test was compiled, it could be printed centrally and sent to the school for administration. In addition to the item bank, the system contained information on lesson plans and instructional resources that were appropriate for each skill area. Teachers could used the data to plan instruction and request supplemental materials.

Recording was required twice a year; using the test questions was optional.

That is, teachers could assess attainment of objectives in any way they chose, including use of the system test bank. The system was designed to be easy to use. For example, with a week's notice teachers could receive a set of pre-printed answer sheets for their class which eliminated the need to bubble in student names and/or code numbers. Once completed, answer sheets were sent to the central office for scoring, and printed reports were produced within a few days. The information could be automatically added to the students' computerized records, thus maintaining updated student records of mastery by skill.

Following pilot-testing of the system in 1982, and with input from teachers, changes were made and the system was implemented in phases, starting with elementary schools. By the time of our visit, the system was installed in all 25 of the elementary schools in the district and in several of the seven junior high schools; all of the junior high school teachers had been trained to use it. The idea was for teachers to enter into the system information on each student's attainment of specific curricular objectives. They could also use the bank of test questions to test the objectives and draw on some instructional resources as well.

Before the system was pilot-tested, schools submitted proposals for involvement in the pilot effort. The four elementary and two junior high schools chosen to participate in the pilot test were selected for their apparent enthusiasm for the system. The phased-in implementation worked in much the same way: schools wrote proposals to be next in line to have the system installed. The major criterion for selection was the potential volume of teacher participation. Having the system installed meant getting a terminal, a scanner, and a printer to which teachers could have access at all times. Typically, the equipment was located in an out-of-the-way place and did not require major changes in physical structures.

Conversations with teachers and administrators revealed that the system was under-utilized. Though large quantities of teacher time and resources had been invested in the development of the system and the training of teachers, and though it was still required for quarterly reporting to parents, its use had become sporadic, varying significantly from teacher to teacher and from school to school. One reason for the decline in use was a growing reaction against the detailed skill objectives that were the focus of the district curriculum. In fact, a superintendent new to the district since the introduction of the information system had pledged to reduce the emphasis on mastery of minute subskills and focus more on broad learning outcomes and thinking processes. This made the assessment system less useful.

The system was not embraced by teachers generally. While they were not overtly resistant, most of those we talked with seemed simply not interested in it. Initially there had been anxiety on the part of teachers about the possibility that they would be evaluated on the basis of how well their students performed. There was some evidence from at least one building principal that he <u>had</u> used the system to pull out information to identify classroom teachers whose students were not meeting objectives. Subsequently the system was changed to make it impossible for principals to obtain class-level data. At the time of our visit teachers still were not using the system spontaneously apart from the mandatory semi-annual reporting requirement.

Many teachers had been involved in the development of the system. Committees of teachers in each subject area wrote test questions for the item bank and developed instructional references. However, once the developmental process was completed teachers returned to their normal duties. In each site teachers and at least one clerk or secretary had been trained to operate the system. Over time teacher use declined as they came to rely upon the clerks as operators. Only among the relatively new teachers we interviewed, many of whom had had some computer experience as part of their training, the task of entering the data was trivial, and they did do it themselves. At one site a teacher who had become a "champion" of the system and assumed the responsibility for promoting it among her colleagues developed some forms to simplify the process of requesting customized tests, and tried to help teachers see the benefits of developing their own. She was not very successful at this, but she did appear to be part of a small core of teachers in the school who used computers for both instruction and management functions, and who were working to interest other teachers in technology. The principal supported these efforts and released her from teaching duties for one period each day.

Since the installation of the management information system, other technologies had been introduced in the district. Shortly before our visit, for example, the district installed Apple labs for instructional use in all schools, the major use for which was word processing in the service of the district-wide writing program. After-school staff development programs involving computer applications were being offered teachers for credit.

The district administration took pride in being ahead of most other districts in the state in computerizing the management function more broadly. There was an electronic mail system in effect, along with electronic paychecks and banking. Demographic and film circulation information were being done electronically, although it is not clear when these innovations were introduced. Apparently, some members of the board of education were responsible for introducing and procuring the management technologies.

The schools also were using microcomputers as part of their instructional programs. Because they were just beginning to explore ways computers could be used, the applications varied from site to site. In one school a computer laboratory had been set up in the library. Teachers brought their classes to that facility and the media specialist selected software and demonstrated lessons. In this way the media specialist served as a model for the teachers. In another school there were two laboratories of computers, one devoted to computer literacy and programming, the other used for a variety of applications of interest to the school's most active computer-using teacher. He encouraged students to explore interesting applications, and tried to promote computer use among the other staff. A small number of computers had been attached to movable carts to permit other teachers to try out applications of interest.

However, the major technology application in this site focused on assessment and the use of assessment to support instructional planning. Though this installation offered teachers the most elaborate assessment system observed in the study, and though teachers had been involved extensively in its development, we observed very little change in the teachers' use of technology. In all fairness, the system was not designed to be revolutionary nor to dramatically change teachers roles. It was hoped that teachers would use it to customize assessment to their own needs, and that they would use the results of this assessment to customize instruction. We saw little evidence that these goals were being met. Though there were many options for teachers, most used the system in the least interactive manner, choosing to enter information about skill attainment at reporting time and using the results to generate parent reports.

There were at least four possible reasons that teachers did not make more extensive use of the system. First, it appeared that few teachers were comfortable interacting directly with the technology. We can speculate that they lacked adequate training and/or they found the system to be intimidating. The schools' efforts to provide alternatives to allow the teachers to obtain the benefits of the system without having to operate it themselves meant that teachers gained little experience with the technology. Because in most school's, other technology use was limited, most teachers were novices as far as computers were concerned. Second, despite the involvement of teams of teachers in the development of the system, the large majority simply were not interested in using it. The system did not seem to appeal to them.

Third, teachers found that the benefits to be gained from the system were not great enough to justify the effort involved in using it. It is difficult to overcome the inertia of the status quo, and it may well be that the added information to be gained from customized testing was not perceived to be worth the cost in time and energy. Only one math teacher demonstrated that she had mastered the art of linking testing to course planning in a useful way. At least one other teacher said that he received all the data he needed from other sources, including regular class tests. Fourth, as noted above, the district was moving away from a skill-based approach to instruction and the monitoring of mastery on many micro-skills. Without this attention to detailed performance the system lost much of its value.

Davis County was clearly a district in transition. While the objectives-based curriculum and the related management information system had been introduced by a strongly centralized administration, the district had been moving, in the years since initial implementation, toward a reform of the curriculum and a pattern of site-based management. The curriculum reform was to increase the emphasis on higher-order skills and more global objectives. Site-based management was giving greater decision-making authority to the principal. Both trends tended to undermine the use of the centralized, objectives-based management information system.

Thus, the introduction of the assessment and reporting system in Davis County did not appear to have wrought noteworthy changes. Nor did the addition of a single administrator for the system alter the organization or administration of the district. The reporting system and its associated hardware was, in fact, the handmaiden of the objectives-based curriculum, rather than constituting an end in itself. If involving teachers in the development of the item bank and training all of them to use the system was intended to spur use of the built-in assessment functions, or to promote teachers' comfort with technology, the strategy failed.

<u>East City:</u> <u>Neptune</u>	Level: Elementary Identified Application: Computer assisted instruction in basic reading, language arts and mathematics skills for selected Chapter 1 students Other Applications: Central office administrative computer, laboratory of microcomputers to be installed in the near future

This site was selected because of its successful use of a minicomputer-based network to provide drill and practice in basic skills. Chapter 1 funds had been used to establish a laboratory/resource center at each school. The centers contained a dozen terminals on a network that delivered CAI software, as well as an area for small group instruction and tables for individual student work. A resource teacher and an aide provided remedial instruction for selected groups of students. Students rotated among the computer, small group instruction from the resource teacher, and individualized written work.

The Neptune II system was introduced into the East City public schools in 1983, following initial training of some staff in its use in 1982. The system had been installed in 50 schools in the district by the time of our visit, having been introduced in "waves" over the years. The program was used mainly in the service of Chapter 1, and had been paid for with district Chapter 1 funds. Neptune was selected and procured through a central process of systematic review (of competing programs) against criteria established by the Technology Division of the East City public school system. The Chapter 1 office was responsible for continuing maintenance of the system and for overseeing its use in schools.

The system was introduced into existing Chapter 1 laboratories for the purpose of providing additional drill and practice to students in grades 4 through 6 who were assigned to the labs. A small number of students, identified at the beginning of the year to receive these supplemental services, were pulled out of regular classes to work in the lab for approximately an hour each day. Their regular classroom teachers did not work in the Chapter 1 lab, but they received reports from the resource teachers about the progress of the students from their classroom. Presumably to minimize the instructional discontinuities that marked pullout programs, the East City system mandated regular meetings between the lab teacher and the classroom teacher to "collaborate," i.e., to discuss the Neptune assignments. The skills included in the Neptune system apparently were not perfectly correlated with the skills prescribed by the East City district curriculum; one Chapter 1 teacher had worked out her own system of integration.

The publishers of Neptune provided a week of training to the Chapter 1 resource teachers, many of whom had also had some computer literacy training offered by the district. Several of the teachers reported that they had used a hot-line that Neptune had established during the early period of use ("an 800 number with a real, calm person at the other end"), for teachers to call if they encountered problems that needed immediate attention; they found it invaluable.

In addition to the initial training, the publishers provided once-a-year events at which teachers using the Neptune system could meet and discuss common concerns. In addition, although it was not clear whether this was a Chapter 1 or Neptune function, the East City system sponsored meetings about the Neptune system and about the teaching of specific skills.

The implementation of the Neptune system meant creating labs, but the labs contained fewer computers (typically eight) than those connected with the West City IBM or CAI projects or NUTEC. And there had been Chapter 1 labs in the schools involved, which had been operating pull-out programs for several years. The eight terminals typically took up at most half of the space in the very large Chapter 1 rooms (also called labs) of which they were a part. The usual organization for instruction in these rooms was for students to spend part of each period at the terminals, part in a teacher-led group, and part in individual activities. Laboratory aides assumed most of the responsibility for the computers, setting up the lessons and supervising the students as they worked at the terminals. This arrangement was not radically different from what preceded the introduction of the Neptune system in that students also worked for part of each period with the resource teacher and for part of the period with an aide.

The technology affected only the resource teacher and the aide directly. While both had functioned in a similar capacity (providing supplemental remedial instruction) before the computers were introduced, the nature of their jobs changed somewhat once the system was in place. They had the added responsibility of operating the equipment, and they had to review and evaluate the information the system provided about student performance. Both received training initially, and the resource teacher continued to attend annual refresher training sessions that were look upon as a extra benefit of the job. Day-to-day management and supervision of Neptune instruction fell to the aides. The resource teachers did, however, plan programs for individual students and establish the sequence of lessons. Thus, Chapter I teachers functioned pretty much as they must have functioned before the advent of the computers.

The computerized basic skills software included a lot of online assessment. Groups of items were used to determine successful completion of lessons and guide student progress through the system. The quality of this assessment was mixed. Some mastery items contained only two or three response alternatives, and the researchers observed students who had learned to complete a unit by guessing and re-guessing until they responded correctly. Test and mastery reports could be printed and shared with teachers so they could monitor student progress and prescribe appropriate lessons. As far as we could determine, the resource teacher reviewed these reports periodically and used them in planning for small group and individual remedial activities in the Chapter 1 lab. However, the reports were seldom shared with classroom teachers, except for those teachers who requested reports to share with parents.

Regular classroom teachers had no direct contact with the technology. They were involved in the selection of students to be taken out of class for remedial work, and they communicated with the resource teacher about the needs and accomplishments of these students, but they did not visit the laboratory themselves. Their roles changed little, and they had only indirect knowledge of the technology and its affects. In fact, it was concern about the level of communication that took place that had been responsible for the Chapter 1 office instituting a formal requirement for "collaboration" between resource teachers and regular teachers, who were mandated to discuss student performance on a weekly basis. The skills-based curriculum made the task of communicating and monitoring progress easier. Each student's progress was monitored on a checklist, and resource and classroom teachers could use these lists as a basis for discussing progress. (The district had received a supplemental publication from the publisher of the CAI software that listed skills by instructional unit, and this made it possible to match the CAI lessons to the district curriculum checklists more closely. However, the task was complex, and it did not appear that anyone bothered to use the cross references any longer.)

Thus, although teachers did not interact directly with the technology, they did obtain information about the impact of the system on students. This may have had an effect on their instructional planning and classroom behaviors, but there was no direct evidence of major changes in these dimensions. Classroom teachers could theoretically accompany their students to the lab but few did because they were responsible for the rest of their students. Some that we talked to had visited the labs to see what they were like; others never had.

The two schools we visited seemed to be using the Neptune system in similar fashion, supporting the notion that the adoption and use of Neptune was a district function, not too readily modified by individual schools. Though the observers questioned the quality, accuracy and usefulness of the software, the Chapter 1 staff were pleased with the computer system and its impact on the schools.

The schools were also using technology to automate some administrative functions. Each school had a computer in the central office with telecommunications capability. These computers were used to gain access to the district computer for recording student attendance informantion keeping and other administrative functions. Both schools were planning for the arrival of 10-15 microcomputers that were to be available for regular teachers and students. No specific applications had been planned yet. At one site one group of upper grade students and their teacher had an opportunity to use a computer lab at a near-by junior high school for introductory and exploratory activities.

<u>East City</u> <u>WTR</u>	Level: Elementary Identified Application: Multi-media introduction to reading program Other Applications: Microcomputer laboratories with various enrichment and remediation software

This school was selected as an example of a successful application of computers to help primary grade students learn to read. A small classroom had been set aside as a learning laboratory for the program, and it was equipped with microcomputers, typewriters, workbooks and supplementary lesson materials. Teachers accompanied their classes into the laboratory on a scheduled basis, and all students had an opportunity to use the materials. Administrators were pleased enough with the program that they had extended participation to include third grade students as well.

The Writing to Read program, produced by IBM, was introduced into a limited number of elementary schools in East City on a pilot basis in 1984. At the time of our visit, the program was operating in an additional 35 schools, with plans to add new schools at the rate of 10 a year. The school we visited had been a pilot site, starting with a kindergarten class in 1984. In each subsequent year, a new grade had been added so that, by the time we visited, students in grades K through 3 were involved in the program and the first class of students exposed to it were in the fourth grade. The principal claimed that he had been told, not asked, to pilot the program, because the district wanted to see how it would work with non-English-speaking students. He was concerned initially about selling it to staff.

In the initial year, Writing to Read supplanted basal readers; teachers were very unhappy about this decision. After the initial year, Writing to Read has been used along with basal readers, and the teachers seemed more comfortable with the arrangement. In subsequent years, as the program was introduced into the first, second and third grades, the teachers involved attended summer training programs in the Writing to Read philosophy and program.

The kindergarten teachers and aides received a week-long orientation before the program was introduced, and attended five day-long workshops during the year. At the very beginning, students, too, received an orientation. Six students at a time were sent to the lab with the aide for several visits over a two-week period. Then and only then did the entire class go to the lab. Although only the aide worked with the equipment, classroom teachers were trained in the Writing to Read philosophy and program, and were expected to go to the lab with their students and take an active part in supervising the instruction. Reinforcement in the classroom of the skills developed in the lab was also a requirement of the program.

The teachers at the school we visited, all of whom had had many years of experience and had all been at the school when the program was introduced, admitted to considerable resistance at first. Their reaction was, "Why do we need this?"? The school seemed to them to be doing fine. It was they who insisted on retaining the use of basal readers, although the program was intended to replace basal readers. Their initial objection was that the program was time-consuming, and they could not get to all of the required skills in the city kindergarten curriculum if they gave Writing to Read all the time it required. They later recanted to some degree, claiming that, as they used the program, they became better at it. At the same time, they also complained that there was simply too much to do in the course of a school day. Several teachers mourned the loss of free play and naps and other traditional kindergarten activities in the rush to emphasize academic skills. The principal, on the other hand, pointed with pride to the fact that there were no cots in the kindergarten classrooms. His view was that kindergarten students had long been underrated.

The program necessitated the hiring of one new staff person and involved some significant changes in the responsibilities of teachers. The heart of the program is a special multi-media laboratory for reading instruction; it contains microcomputers, typewriters, audio recorders, work areas and other materials. The new position of laboratory assistant was very similar to the laboratory technicians that were employed in some of the other sites. In this case the equipment was easier to operate (microcomputers v. minicomputer networks), so the lab assistant was available to help with instruction and supervision. In East City, each primary level classroom visited the laboratory for one period per day. Teachers accompanied their students and were responsible for providing instruction in the laboratory. The laboratory assistant was responsible for the setup and operation of the computers and other equipment. The principal explained that the laboratory assistant was hired to insure that "the teachers don't have to touch the machines." In this way they could concentrate on instruction with no concern for operating the technology.

Teachers experienced a significant change in behavior, though there was little change in their overall role. They continued to be viewed as instructional leaders, even though they were required to adjust they manner in which they taught reading during the time they were in the lab and to change their curriculum and their schedules to accommodate the new approach. For example, they had to include lessons to help students make the transition from phonetic to standard spelling. Their presence in the lab gave them an opportunity to observe students learning with computers, but their responsibility for working with small groups at the other stations lessened the time available for such observation.

The Writing to Read program does not have a specific assessment component, though having the teacher involved directly in the multi-media lab probably provides the most meaningful feedback one could possibly use.

Only one school of the 35 that had introduced the program was visited. This school's approach to implementation seemed to be a good example of patience by a fairly enlightened principal, who took teachers' concerns to heart in deciding how to administer a program of mandated technology. From initial resistance on the part of teachers, he had won, first, grudging acceptance and then approval of what the program was accomplishing.

In addition to the reading laboratory, the school had two microcomputer laboratories that were used with upper grade classes for various enrichment and remedial activities. There was a microcomputer in the principal's office, that could be used for word processing and other applications.

<u>Lenape</u>	Level: Elementary, Junior HIgh and High School Identified Application: Exploration of curriculum-related software in many subjects, with an emphasis on higher-order thinking Other applications: Programming, instructional television, vocational programs incorporating CAP-CAM systems and computer repair

This site was characterized by enthusiastic exploration of the use of microcomputers as instructional tools in a wide variety of ways. For example, the computer coordinator, who was responsible for promoting computer use, had developed a program that focused on higher order thinking within the curriculum. Actual use varied from site to site and from teacher to teacher, though all applications at the elementary and junior high levels revolved around a core of activities suggested by the coordinator. An equally enthusiastic high school principal encouraged teachers to apply computers and other technology in as many ways as possible.

Lenape in 1984 had no computers save some antique machines acquired by individual teachers for idiosyncratic purposes. Some teachers had received six hours of training in BASIC through a state network, but there was no particular resident expertise in technology. Implementation started with the appointment, by a superintendent with a strong desire to introduce technology into the district, of a computer coordinator. The coordinator was given authority over all administrators in the district. The charge to the coordinator had been to establish a computer program that would be coordinated across all schools in the district (three elementary, one middle and one high school).

The impetus for promoting technology came from the superintendent, who created the position of district technology coordinator for a specific individual he hired to develop and implement a program for the district. Though this person shared the same title as three other district curriculum coordinators, his job responsibilities were quite different, and he seemed to enjoy greater autonomy than the others. In many ways he acted independently, crossing disciplinary lines as well as grade levels in his efforts to integrate computers into the instructional program. The technology coordinator hired a new technology specialist who divided time among the three elementary schools and worked directly with teachers. The specialist trained teachers to the operate computers, introduced them to software, taught model lessons, and helped supervise students in the computer laboratories that were set up at each school. These two new positions were created as part of the technology effort.

The overall approach was what the coordinator labeled one of "curriculum infusion: looking at the curriculum for areas that might be improved by electronic education." While it was difficult to tell in what order the various elements of the program had been introduced, the district had established computer labs in each of the elementary schools, two in the middle school and six in the high school; hired a computer teacher; installed a satellite dish and a weather station; established relationships with local colleges for training teachers in various computer applications; and created a summer program of computer education for teachers in other districts.

The coordinator trained each of the other area supervisors (the administrative structure included a series of supervisors who were responsible for their subjects in grades K through 12) in the uses of technology, and made good use of the support he received from the high school principal, who backed a range of technology projects. The coordinator appeared to act as a cheerleader for any individual teacher or staff member who wanted to try a new piece of hardware or software, or to attend some technology-related class or training activity.

The coordinator also introduced administrative computing in the district. In the high school, computers were provided for the principal and vice principal, for the office and guidance staff, for the attendance officer, and for the school nurse. In the middle school, computers were made available to the principal and vice principal and the guidance office. The goals of these introductions, which proceeded as quickly as funds and resources became available, were to incorporate technology across all school functions and to increase appreciation for technology among teachers and students.

At the time of our visit, each elementary school had a laboratory equipped with microcomputers and a variety of software. A computer resource teacher divided her time among the three elementary schools, introducing teachers to different computer applications and teaching demonstration lessons as a way to model the instructional use of computers. At the junior high school a laboratory of microcomputers linked over a network was used for teaching programming and database applications. Another laboratory of microcomputers was available for other uses, and individual microcomputers were used by interested teachers for curriculum specific tutoring and enrichment. There was a great variety of technology use at the high school. A small cluster of computers was used by the science department. Microcomputers were used for language arts instruction, for teaching programming and for specific applications in other subject areas. The school had a satellite antenna for reception of television broadcasts, and they were experimenting with the use of foreign language television in teaching foreign languages. The district technology coordinator encouraged teachers at all levels to explore interesting applications of technology; he also made sure that teachers had access to the necessary hardware and software.

Because technology use was so diverse in this site, changes in roles and responsibilities were more difficult to detect. Furthermore, the innovation was relatively new, many applications were just beginning and changes were still in progress.

The coordinator, given a free hand to introduce technology across the curriculum, served as catalyst, trainer, reviewer and procurer of equipment and software, repair person, and cheerleader. He had been given a budget of $50,000 as seed money and told to write grant proposals for additional funding for the technology. He became quite successful at this, attracting new sources of funding to the district and creating, in the process, new partnerships with entities outside of the school.

The goal of the district's technology program was to integrate computers and other technology into instruction as broadly as possible. The coordinator took this responsibility seriously, and tried to influence all the teachers to make greater use of computers and other technologies. Every teacher was influenced to some extent. However, because the focus of the effort was integration into the existing curriculum, there were few major changes in teachers' roles. Most continued to have the same responsibilities while making somewhat wider use of computers in carrying them out. Implementing of this goal was somewhat different at the elementary and secondary levels. Elementary teachers were encouraged to incorporate computers into their lessons, and they were given technology-based curriculum ideas and an opportunity to observe model lessons. Secondary teachers were also encouraged to explore technology, but they were more on their own to develop applications. Teachers who expressed interest in technology were supported in a variety of ways. They were encouraged to take courses in technology-related subjects, given help that they needed in acquiring hardware and software, and accorded recognition and praise by the district (not necessarily their school) administration.

In his planning role, the computer coordinator made some organizational decisions that affected instruction. For example, he made a very deliberate decision to supply all computer labs at the elementary level with between one-third and one-half the number of computers as students in a typical class. Entire classes visited the lab, and the students worked in teams of two or three, presumably to encourage cooperative learning. It was required that teachers accompany their students to the lab. Because there was only one technology specialist for the three elementary schools, the coordinator worked out a schedule that had her (the computer lab teacher) spend six weeks or so at each school, and leave classroom teachers with programs of instruction to continue after she had left, effectively compelling teachers to oversee the computer activities of their students. The software in the labs was chosen to provide enrichment and activities involving higher order thinking skills. In selected instances in which he felt a reluctant teacher would not have ventured into the lab otherwise, the coordinator agreed to provide teachers who requested them with drill-and-practice programs for their students. There was no specific assessment focus to this sites efforts to integrate technology into the curriculum. One area of attention was higher order thinking skills. Teachers said that this curriculum improved students' performance, but it did not make use of technology for assessment purposes.

As noted above, the coordinator forged a number of new working relationships with constituencies beyond the schools and outside of the district. Lenape became part of several state technology networks, one with a state technical college, another related to science curriculum. Programs for parents ranging from computer classes to sessions on how to acquire and use home computing equipment were held several evenings each week. Cooperative arrangements had been forged with the local community college and with area businesses in which training of college and business personnel was provided by the school district and additional computers were provided for the schools by the college and businesses.

Most people who were interviewed were enthusiastic about the use of technology, though they admitted they were only beginning to investigate different applications. Some resisted the pressure to change their pattern of teaching, and one school administrator was openly antagonistic to the initiatives of the computer coordinator. Because of the newness of the activities and the reluctance of some to participate, it seemed that the overall success of the district effort was only moderate.

Metro City	Level: Junior High School
	Identified Application: Programming using LOGO in a variety of subjects
	Other Applications: None

This alternative school was selected because it represented a somewhat unsuccessful attempt to use the LOGO programming language to promote creativity and self-directedness among students. The school was founded with the goal of implementing many of the ideas espoused by Seymour Papert, the developer of LOGO, to harness the power of microcomputers for intellectual exploration. Though it started with a highly innovative and unusual focus, what had evolved was a more traditional instructional pattern.

In one sense, the school itself was the innovation. It was an entity established for the purpose of embracing computers in education, and integrating their use across the curriculum. Set up as an alternative junior high school in one of Metro City's decentralized districts, the school was opened after several years of thinking about and planning for a "school of the future." The central focus of the school was to be a curriculum developed around the LOGO language. The school's sponsors, originally the Metro City Academy of Science and the Media Learning Laboratory at MIT, arranged for the donation of 30 IBM PCjrs and 14 Apples.

The Computer School was located in a larger junior high school. A prolonged search was conducted for a host school that had space to accommodate The Computer School and a principal willing to accept the building modifications required by the introduction of 30 machines. Originally housed on the fifth floor of a multi-story school building, The Computer School was forced to move at the end of its second year to a basement space in a different junior high school. In both instances, there was considerable retooling of existing classrooms to accommodate the machinery and the need for increased security; in both instances, Computer School staff invested considerable energy in devising layouts of classrooms and equipment that would serve the instructional goals of the school. For example, the main computer lab was rearranged several times in the interest of improving the management of the classroom and the instructional climate.

Teachers were hired, brochures created, a building located, and a group of about 150 students recruited for the opening of the school in September 1982. Delays in the procurement of the computers meant that the school functioned simply as a junior high school for most of the first year. When the computers and LOGO software were finally delivered, in the middle of that first year, they were more like adjuncts to an ongoing program of education than the central focus they were intended to be.

Two classroom were equipped with microcomputers, and each of the approximately 150 students in the school spent one period a day using a computer and working with LOGO. In addition, the seventh grade science class frequently used one of the laboratories for science-related computer tutorials and simulations. As interest in other microcomputer applications increased over time, the second lab was used by other classes for word processing and other general purpose computer tools. Though initially all the teachers were committed to using computers in instruction, over the years this goal was not realized. Other instructional priorities took precedence over the use of computers for some staff. At the time of our visit roughly half of the teachers were using computers for instruction and half were not.

In 1983, its first full year of operation, the Computer School floundered. There were hardware problems and no systematic mechanism for dealing with them; disagreements between the school sponsors and the teachers about what it actually meant to build a curriculum around LOGO; and conflicts among the teachers themselves about what the priorities of the school were. The students posed a host of instructional and management problems. There was no real leadership (a pair of teachers had been released from teaching half time to serve as "co-coordinators"). Given this level of confusion, the original sponsors lost interest in the school and turned their attention to other projects, leaving in their wake the school, the computers and software, and a cadre of teachers trained in LOGO.

During that school year, the staff attempted to create a curriculum based on the hardware and software at their disposal, develop a workable management structure for the school, and establish a working relationship between the school and the district and between its own goals and those of the Metro City curriculum for which it was accountable.

Ground rules were established. All students would visit the computer lab for one period a day, and "computers" would be treated as a major subject. The focus of the school would not be technology <u>per se</u> but, rather, the use of the technology as an aid to instruction and as an integrating influence across the curriculum. Every attempt would be made to find new opportunities to integrate the discrete subjects taught, including the LOGO language and computers, into curriculum units.

Thus, there was no real "implementation" of technology in the Computer School in the sense (as was the case with the other sites represented in this study) that technology was introduced into an existing school. The technology was the reason for the school, even though the objectives of the technology were not fully realized from the start. The teachers continued after the initial year of re-grouping to attempt to create an identity for the school and a unique curriculum as much as they continued to search for ways to integrate the resident technology into their instructional goals.

The teachers were all new to the school when it opened. The non-traditional (and frequently-shifting) organization required that teachers take more responsibility than was traditionally the case for school-level decisions and for their own classroom curriculum. At the same time, team teaching and curriculum modules that crossed subject areas meant that most teachers did not have to plan instruction alone. During the five years of The Computer School's existence, the staff have experimented with a number of different structures and schedules to accomplish the evolving goals of the school. The experiments involved different configurations of classes (combinations of grades, combinations of subjects) in order to make best use of the teachers who had volunteered to join the staff initially as well as the changes in staff that occurred over the years. The experiments also represented attempts to use the computers and the computer expertise available among the changing staff in ways most suited to the goals of the school. In fact, a certain organizational flexibility has marked the history of the school, a flexibility made possible by its small size (150 students, nine teachers), and its status and mission as an alternative school.

Over time, as it became clear that not all of the teachers were interested in accommodating their instruction to the technology, a limited number of teachers assumed responsibility for the computer applications. Two teachers were responsible for introducing students to the LOGO language at the beginner and more advanced levels; one teacher managed the lab in which a variety of applications could be carried out. Thus, a kind of specialization developed in which some teachers worked with and developed new applications of LOGO. These might be integrated with subject area instruction or independent of it.

To be sure, its status as an alternative school has also created constraints for The Computer School. Dependent upon the willingness of the host school to allot space and to share facilities, The Computer School was or was not able to offer its students such amenities as physical education in any given year, or to schedule lunch periods or outdoor time flexibly. Moreover, school staff never know, from one year to the next, whether the school will continue in its current location. And the current basement location has created a need for tightened security, which translated into a limit on the goal of allowing students access to computers before or after school.

Despite the potential for doing so, The Computer School did not use technology for assessment. The focus of technology use was on exploration using LOGO and creative thinking. The teachers who taught the LOGO language did use printouts of students' programs to assess their facility with LOGO such printouts might be displayed as evidence of particularly noteworthy work.

There was also a wide range of computer use by teachers. Few teachers even maintained their tests on disks. This was consistent with an observed lack of technological sophistication in carrying out most routine functions at the school, despite its name and educational mission.