1993

Technology: Review of Literature Executive Summary

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TECHNOLOGY
REVIEW OF THE LITERATURE
Executive Summary

Prepared for the Virginia Department of Education

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February 26, 1993

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Preface

This review was commissioned by the Virginia Department of Education during the development of the state master plan for Technology. Fifty-one questions were posed to guide the review (see Appendix B). The information found in this review and its supportive annotated bibliography makes it possible to approach technology decisions with a healthy blend of informed instinct and analytical deliberation.

This review focuses on the application of technology (primarily the computer) to education. It is organized to present background information to familiarize the reader with basic issues relevant to teaching with technology, the restructuring of American schools and the performance one could expect from the infusion of technology into the schools and classrooms. It summarizes findings regarding access and equity, inservice and preservice education, and funding and facilities.

Considerable research has been conducted on the effects of technology, access to technology, gender bias, and surveys of teacher use, but little scholarly attention has been paid to the changing role of the teacher in a technology intensive classroom or to technology's relationship to restructuring. It is in these two sections that this review extends the research and makes its major contribution.

The project team was composed of research assistants Jeanne Schlesinger, Amanda Parks and John Pisapia, project director. Ms Judy Scardina provided able assistance in document formulation and editing. Susan Goins assisted the team and study group in meeting arrangements and document preparation.

John Pisapia
Project Director

Executive Summary

The literature review focuses on the application of technology (primarily the computer) to education. It is organized to present background information to familiarize the reader with basic issues relevant to teaching with technology, the restructuring of American schools, and the performance one could expect from the infusion of technology into schools and classrooms. Furthermore, it summarizes findings regarding access and equity, inservice and preservice education, and funding and facilities.

THE TECHNOLOGY RATIONALE

After a decade of enthusiasm, there still is no single compelling vision driving the infusion of technology into the schools; four have been projected.

1. **The Social Rationale.** Policy makers want to be sure that all children are "aware and unafraid of how computers work". They should be prepared to understand computers and be aware of their role in society because computers are pervasive in industrialized countries.

2. **The Vocational Rationale.** There will be employment opportunities for individuals who have the proper computer skills. Therefore, it's an important competency to develop.

3. **The Pedagogic Rationale.** Students can learn from computers. There are advantages over other traditional methods in using computers to learn.

4. **The Catalytic Rationale.** Computers are catalysts to change schools for the better. They can facilitate change. They are symbols of progress. They encourage learning (Hawkridge, 1990).

TECHNOLOGY AND RESTRUCTURING

Technology by itself cannot restructure schools, however, schools cannot reach excellence for all children without it. The conclusion drawn by many is that technology has an essential -- though not independent -- role to play in boosting educational productivity.

The role of technology in support of restructuring is an evolving one. It can support traditional models by standardizing and automating procedures. Applications such as CAI, mastery learning curriculum, and programmed skill packages make existing practice better.

However, it is believed that only certain learning tasks can be routinized. If the goal of restructuring is to move to a learning environment that emphasizes complex problem-solving, decision-making and value judgments that are not easily codified, then technology has much to offer the restructuring movement.

In fact, there is a growing consensus that any major investment of time and effort in technology can only be justified if teachers use the technologies as tools, in ways that emphasize application, word processing, simulation, and program problem-solving.

The pace of technology makes assimilation difficult, but there seems to be a natural progression in teacher use of technology. Firstly, observers believe you change the way people think about teaching and learning, and then apply technology. You cannot apply technology first and expect to change the way people think because they will just apply the technology in old ways.

Secondly, as teachers become more familiar with technology, they use it less for drill and practice and more for word processing and databases. Restructuring schools can use this natural progression by organizing for it, putting technology into the hands of teachers, integrating it into the curriculum, allowing experimentation by teachers, inferring

knowledge about possible uses after teachers have reached a comfort level with the technology, providing adequate time to learn and develop, providing sufficient amounts of hardware, keeping success stories in front of teachers and removing the classroom from isolation.

TECHNOLOGY AND INSTRUCTION

Technology can help create a rich learning environment. This potential depends upon the teacher's ability to integrate the technology into everyday classroom activities. Integration requires a great deal of effort by the teacher. However, used appropriately, it can reinforce, supplement and extend student skills.

Technology can also support either the **traditional or learner centered instructional philosophies**. Traditional teachers use it as a medium for drill and practice and tutorials. Learner centered teachers use it as a tool for problem-solving, taking advantage of the word processing, database, spread sheet, graphics and telecommunication applications. Technology enables teachers to reinforce their instructional philosophy or transform it.

If adopted, technology can have an impact on teaching style, instructional philosophy and goals at each grade level, resource allocation and on instructional materials.

One of the most significant impacts of the computer is on **teaching style**, even though most observers feel there is no "best way" to teach or learn. While some people think both the teacher and learner-centered approaches have their places, the technology empowers the teacher to function as a facilitator of learning rather than acting in the traditional role as transmitter of ready made information.

It is generally acknowledged that teachers are **critical to integrating technology** into the learning process. They make the decision to integrate the technology, make it an internal part of their technique or use it as an add-on, a "treat" or reward. The general consensus is that as a result of the adoption of technology, the **teacher's role** changes from

presenter to coordinator of learning resources and frees the teacher to work individually with students. They move from being the "sage on the stage" to the "guide on the side."

There seems to be a sequence from teaching without technology and becoming an **accomplished integrator**. Teachers adopt innovations in light of their own goals, accustomed practice, culture of their community and school, and their own interpretations of the information they receive about new approaches. Therefore, it is appropriate to find uses of technology that support the instructional philosophies teachers have identified.

Teachers vary the use of technology-based on their curriculum goals, assessment of student need, and preferred teaching approach. Technology-using teachers use technology in different ways: drill and practice, tutorials, simulations, problem-solving and productivity tools. The types of instructional decisions they make are dependent on their knowledge of possible uses, availability and ease of use of the technology, and their instructional philosophy. As their philosophies change, as in restructured schools, the technologies and applications they use will change also. For example, teachers generally start with drill and practice and move to applications.

There are grade level differences in the use of technology. For example, **instructional use differs** by grade level. In elementary, drill and practice and tutorials are emphasized. Middle schools and high schools emphasize word processing, discovery, problem-solving and productivity tools. Its potential is to not only reinforce lessons, but as a tool to support the development of minds from pre-adolescent through adolescent phases.

Technology applications are also emphasized at different graded levels. At the elementary and middle schools, one finds more use of integrated learning systems (ILSs) than at the high schools. And, in the high schools, there is more use of video disc, CD ROM and database than the elementary and middle schools.

Teachers' use, on the other hand, is similar across all three levels, except that high school teachers don't use it to create banners for room decorations as do elementary and middle school teachers.

Curricular emphases also differ by grade level. In elementary, computers are used in math and language arts. Middle school use is more in general math and sciences. Mathematics and science are the focus in high schools. One of the most difficult barriers in **curriculum reform** has been the reluctance to drop existing content. Yet, technology-using teachers are four times more likely to introduce new topics and five times more likely to de-emphasize certain topics than nontechnology-using teachers.

Resources also appear to be allocated differently across grade levels. For example, elementary schools seem to prefer to distribute their computers. In 1986, only seven percent of the K-6 schools had at least eight computers linked while high schools had linked twenty-four percent of the high schools.

Finally, the impact of technology on **instructional materials** has not been fully felt as of yet. However, several incidents portend future developments. The definition of the textbook is beginning to change. For example, the technology to produce customized textbooks exists, but it is not being utilized on a large scale. Most recent trends include the following activities. In Texas the word "textbook" means any instructional material that meets curriculum requirements. In California it means textbooks and video discs. Florida law allows the state board of education to adopt technology in the textbook process (Mageau, 1991). The 1992 New Grolier Multimedia Encyclopedia is a CD ROM based multimedia encyclopedia containing 33,000 articles. It has new multimedia elements such as digitized video segments of historical events, famous people, and automation sequences.

TECHNOLOGY AND STUDENT PERFORMANCE

In general, student **performance can be improved** through the use of learning technologies. Specifically, a meta analysis of 184 studies of learning technologies concluded that, on average, a student performing at the 50th percentile will perform at the 62nd percentile on the standard normal curve.

It is also clearly evident that **performance varies**. Therefore, strengthening implementation protocols and processes will produce substantially better results. For example, the fluctuation of results by type of achievement measure indicates that teachers must address alignment and assessment issues prior to assessing the results of their instruction.

Purchase decisions can also be improved when based on a clear description of the educational problem the user is trying to solve or the opportunity they are trying to provide students through learning technologies.

The following points illustrate the **impact of technology on performance**:

- CAI and ILS applications are effective for teaching mathematics and language arts. There is preliminary evidence that multimedia may produce similar results in science.

- Newer technology applications are more effective than older applications.

- The technology in mathematics, language arts, and science proved to be educationally significant in terms of results.

- The effect of technology on at-risk students is promising.

- Learning technologies raised scores 1) substantially on locally developed teacher/researcher district developed examinations; 2) moderately on state/regionally developed criteria referenced tests; and 3) moderately on standardized norm-referenced tests.

- The write to read results were negligible and not educationally significant for reading, and substantially and educationally significant for writing.

- ILSs demonstrated educationally significant results on standardized tests; and with at-risk students.

- There were few studies found that examined the effectiveness of the use of technology as a tool. In fact, these applications require that new assessment strategies be developed.

Finally, if technology is to demonstrate its potential value, then there needs to be a movement away from standardized test evaluations and toward authentic assessments.

TECHNOLOGY AND ACCESS

Computers are pervasive in the schools. If progress is judged on the amount of hardware and number of students using it, then progress has been made. For example, in 1989, the ratio of students of computers to schools was 6/1 at the elementary level and 21/1 at the high school level. However, **access** continues to be an important issue regarding equity, gender, location of the computers and disparity.

The findings on **equity** are mixed and somewhat confusing. On the one hand, the ratio of students to computers was found to be nearly twice as favorable for schools containing low SES students. Yet, others report that students with high minority enrollment have less than one-half the computer access compared to students with majority enrollments. Socioeconomic factors play a disturbing role in low SES student

access to computers, particularly at the elementary school level. This trend disappears at middle school and high schools, but it may be too late by then.

Equity in school computer use must involve not only equal access, but also consideration of the learning needs of poor, minority and female students. This means that equity must be a priority, a part of every policy decision and every classroom action.

Gender differences are also of concern. It has been reported that instruction based upon cooperative modes rather than competition is preferred by females. If this is the case then the move from traditional uses of technology to more contemporary use as tools has the potential to reduce gender bias and make the technology more attractive.

Some observes feel that **placement of the computers**, rather than the total number, is the key variable in defining access. The literature portrays some doubt as to where the computers belong in the schools. But it is clear that student utilization depends on organization of computers in labs or classrooms and the availability of appropriate software.

Other problems exist with **connectivity** beyond the school day. The futurists say it won't be a problem because in the future, every student will have a lap top with a modem to access whatever information or tools they need. Though not considered a serious problem by most observers, it is a concern today.

Telecommunications is linking education to the world. It is being used in education to increase information access and reduce **disparity** through television, satellites and distance education. These technologies are eliminating barriers of time, geography or local expertise. Rural students are using them for meeting graduation requirements and urban students use them for low cost field trips. Minnesota and Memphis demonstration

sites use them for distance tutoring. Several states use it to deliver courses to meet graduation requirements. Others use it to enrich the classroom through programs such as CNN Newsroom and World Classroom.

Finally, what does seem to be related to exemplary uses of technology is **administrative leadership**. Administrative actions to insure equity in access to different categories of students such as sex, ability, and ethnic group are three times as likely to be found in schools where exemplary technology-using teachers are found.

TECHNOLOGY AND TRAINING

Any plan to make greater use of technology must include teacher training. Yet, relatively little scholarly attention has been paid to changes in the role of the teacher due to technology intensive classrooms. However, the research is clear on two points: 1) the process by which teachers appropriate technology is more complex than that by which they adopt other changes, and therefore it takes time -- five to six years -- to master teaching with computers, and 2) the lack of teacher training is perceived as an issue most likely to impede the advancement of educational technology, second only to funding in importance.

It takes about five years to become an accomplished technology-user. It requires the teacher's motivation and support from colleagues, schools, school districts, colleges and departments of education.

Teacher training and preservice education can both be improved by understanding the characteristics of the five percent of the teaching force who are considered exemplary technology-users. For example, they had 1) more formal training in using computers and teaching with computers, 2) more specific training on how to integrate software into existing lessons, how to organize class activities to allow computer use during class time, and word processing and other computer applications, 3) learned applications through self instruction and spent twice as many hours personally working on computers at

school, and 4) progress from applications that directly reinforce what is being taught, such as drill and practice, to those that are more expansive, such as tools.

The **types of training** required are: 1) skills needed to work with technology, 2) education that promotes vision and understanding of the possibilities of state of the art applications of technology, and 3) skills to revise and modify courseware. A three-tier approach to training is recommended. The first tier involves the minimum expertise needed to operate the technology. The second tier involves new educational skills: classroom management and the integration of technology into the curriculum. The third tier involves annually skill updates to allow for new developments. Exemplary technology-using teachers recommend that training start with one application that is easily used and quickly adopted.

The literature identified colleges of education, school districts, regional service centers, professional organizations and private corporations, including vendors of hardware and software as potential deliverers of technology training. Regional centers are playing a growing role in training. In fact, seventy-five percent of the states sponsor training through centers, and twenty-two states use electronic networks to provide training.

With regard to **preservice education**, the perception is that prospective teachers are: 1) not being educated to integrate technology into the classroom, 2) being taught by instructors who lack expertise with the computer, 3) ill-prepared to teach with computers, and, 4) attribute less value to using computers than business school majors.

However, in 1988, ten of the fifteen largest teacher training instruction programs included a computer literacy requirement for graduation. Two years later, the number had risen to twelve. There is a trend among colleges to start with separate classes before proceeding to offer more comprehensive approaches.

Several conditions must be met if colleges can produce teachers who are knowledgeable and comfortable with teaching with technology. For example, students and faculty must have access to hardware and software equivalent to what they will find in the classrooms they will enter. Expanded activity requires expanded capacity.

Prospective teachers should be immersed in an environment that requires them to use technology to improve communications, increase productivity and enhance the teaching/learning process. Several models appear in the findings that are worth investigating.

Based on the existing research, it is difficult to predict the effects of technology on the skills required for teaching. A basic premise is that teachers will need to possess all the skills currently required in addition to the new skills made necessary by technology. There are few explicit pedagogical models existing for teachers to emulate when trying to integrate technology and teaching. This condition has led school districts to establish the operational criterion for selection as "interested, experienced, and appropriately educated."

However, year 2000 educators (whether they are classroom teachers, central office, or state department personnel) will have to be engaged in a range of functions rather than perform only specialized tasks. Instead of increasing specialization, all members of an organization must possess a core set of knowledge skills and attitudes that are redundant in all organizational members such as collaborator, mentor/mentee, planner, researcher, and seeker.

TECHNOLOGY AND FUNDING, FACILITIES AND EQUIPMENT

Funding has been and still is the most important issue in the advancement of educational technology. At the current rate of investment, states can expect broad experimentation, continuing equity questions and slow but steady improvement in access and software.

The state has a special role in funding to provide equal access within schools and within classrooms. State funding is mixed with funding from the federal government, business and industry, software publishers, hardware vendors, and private foundations. Currently, the major sources are 30% state, 10% federal, and the majority (60%) from local funds. There is a general consensus that all potential sources need to be encouraged to participate because the size of the investment is large. More importantly, what is needed is a steady funding source that can provide a steady base funding source.

Several **funding options** have been suggested to get a more steady funding base at the legislative level such as: adjustments in the foundation program, earmarking permanent school funds, and short-term bond financing. Creative financing strategies such as grants and contributions from the private sector, using the textbook fund to purchase software, low interest loans, and special innovation funds have also been suggested.

The most widely held **justification for state funding** is to improve access and support integration of technology into the everyday life of students and teachers. State funding priorities have been distance learning, software and video preview centers, electronic bulletin boards, and development of instructional TV. School districts are using federal and local funds for technology hardware.

Telecommunication and computers are merging. This fact is putting pressure on current **facilities** and requires design changes in new schools. The most noticeable changes will be in the classrooms and laboratories. More space and flexibility of costly equipment will be needed such as science and language laboratories and closed circuit television.

The **equipment** most commonly associated with the modern classroom are instructional television, the video cassette recorder, the microcomputer, and the interactive computer-based video disk machine.

TECHNOLOGY AND PLANNING, IMPLEMENTATION AND EVALUATION

Planning for the use of technology should be focused on four key concepts that characterize the direction of educational technology. First, educational technology will be **interactive and controlled by the learner.** It will engage the student and enhance decision-making and problem-solving. This fact alone will revolutionize the classroom and the place we call school.

Secondly, educational technology will make **resources more accessible**, changing the place of schooling, the role of the teacher, and the relationship between teacher and learner. With massive data bases, with visual images immediately available, the teacher will no longer be the holder and dispenser of information and the trainer of skills. Teachers will be more like coaches, mediating technology, diagnosing learning styles and proficiencies, and facilitating a variety of strategies.

Thirdly, educational technology will be **more affordable**. It will be in reach of all learners, both in and outside the school.

Finally, educational technology will be **integrated**, bringing together may tools in an exiting and creative fashion. The merging of computers and video technologies with telecommunications is already in the current system (Farley, 1992).

Planning for technology is an **important state role**. The justification for state involvement revolves around equity of access to resources, coordination of resources, and developing infrastructures that allow information sharing and alleviate disparities. The planning model chosen by a state is generally dependent on tradition and the manner in which they handle major reform efforts.

States use a variety of mechanisms to develop state technology plans. They can be conceived through a task force structure composed of key constituents who develop a consensus around the components of a master plan. These constituents would be

external to the department of education and would include businesses, the legislature, professional associations and members of the general public. The task force is responsible for presentation of the plan to the appropriate decision-making bodies. In this model, the department of education acts as staff to the task force, providing information and being responsible for the mechanics of putting the plan together. Secondly, once the decision-making bodies (such as the State Board of Education) review the plan, they are responsible to amend the plan in accordance with the decision-making body's recommendations. Finally, under this model, the Department reverts to its managerial role of implementing the plan through budget requests, and if successful, through implementing decisions and tactical plans to implement the components that survive the decision-making process.

A second model used is to develop the Master Plan in-house. While this committee is generally composed of department members, it also includes members of professional associations and the professional community. This model generally has some public input and review process such as public comment periods in the drafts that are forthcoming from this process. At the conclusion of the work, the plan is submitted to the executive level of the organization who recommends changes, and then to the public decision-makers for review and prioritization of components of the plan. After producing the first draft of the plan, the department's role is similar to the task force model.

No matter which overall planning structure is utilized, the process will generally use an adoption, political market place, a concern based strategy, or some combination of the three, such as strategic planning process. Each strategy has its strengths and weaknesses and they are detailed in the findings.

The **state master plans have focused** on hardware acquisition, software acquisition, evaluation, distribution, staff training and development, electronic linking of agencies and sources, integrating technology into instruction, encouraging local school divisions to plan

for the use of technology prior to the purchase of equipment, and providing financial incentives and cooperative purchasing agreements.

Distance learning has become a staple of state efforts and is evident in nearly all state plans. Some leading states have created centers for research, development, dissemination, demonstration and evaluation of technology and software. Others have created demonstration schools. The emphasis there is to marshall all the resources for integrating technology into the daily life of a school. Others have focused on creating electronics networks to connect the schools to the world. Others have moved to establishing a statewide administrative management information resource.

State plans generally require or encourage school district planning. If there are state funds available for technology, they require it prior to the release of funds. Some may even help school districts write informal, appropriate plans on the use of technology and help determine needed software.

It has been demonstrated that **technology can do the things it promised**. A majority of states have developed plans. Many school districts have developed plans. However, judging from the incomplete diffusion of technology in the schools, it is apparent that either the best uses of technology have not been reached or there has been insufficient funding for its installation.

The lack of **systematic implementation models** to follow, incentives for individual teachers, limited amounts of equipment and the unsystematic use of software, primarily at the lower grades, have been identified as barriers. The facilitators of technology implementation are seen as the attitudes of teachers and administrators toward the innovative uses of technology, a good understanding of user perceptions, communication of possibilities and successes, and allowing sufficient time for a consensus to be established. Most essential is the existence of a core of enthusiastic technology-using

teachers and a dynamic supportive administration that, together, provide the leadership to design and implement the plan.

The **role of evaluation** is nothing less than to provide: 1) policy makers with the information they require to contribute to their decisions to enhance or expand technology, and 2) designers' and users' information which will contribute to improvement, continuance or expansion of their programs. As important as evaluation is the state role that has been limited.

Most progress has been made by learning by doing. A few states require that the components of their master plans be evaluated periodically. Some require an evaluation component for every technology project they fund. California has been a leader in this area. They require formative evaluations of each of their demonstration schools. Cost-effectiveness has been much proposed and advocated, but there is little evidence that rigorous studies have been conducted or utilized.