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ABSTRACT

The use of computer technology brings profound changes that demand a need for rethinking the role of public education. This report's purpose is to assist educators in shaping the future role and nature of the public schools. The report centers on two aspects of the change: the economic context and the evolving educational process. The work world will change dramatically, and these changes have significant implications for the schools' curricula, standards, and teaching methods. The workforce will shift from highly paid skilled jobs to low-wage and low-skilled jobs. The demand for reeducation will increase as people prepare for several careers subject to rapid changes. The education process must adapt to the changing needs of the labor force. The teaching-learning process is being transformed by the computer and provides more individualized instruction and faster and more expanded learning opportunities. Reviewing the application of computer technology, the report points out how existing educational problems are being solved with the new technology. Policy questions and options are also presented, including rethinking curriculum, equipment needs, teacher training and retraining, and financial considerations. (MD)

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SCHOOLING & TECHNOLOGY

VOLUME 2

The New Equation: Student, Teacher, Unlimited Information

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The Southeastern Regional Council for Educational Improvement is a nonprofit, interstate organization created and governed by the Chief State School Officers of 12 southeastern states. A major function of the Southeastern Regional Council is to assist member State Departments of Education to study educational policy issues within the social, political, and economic context of the region and to design alternatives for policy action.

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SCHOOLING AND TECHNOLOGY

Volume 2:

The New Equation: Student, Teacher, Unlimited Information

July 1983

Southeastern Regional Council for Educational Improvement

EDUCATION FOR THE FUTURE

THE SOUTHEASTERN REGIONAL COUNCIL FOR EDUCATIONAL IMPROVEMENT

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FOREWORD

The term "technology" is used in this publication in a particular context that deserves explanation. Technology is simply "the application of knowledge to practical purposes" – a definition which applies equally to a ball-point pen or a microcomputer. Furthermore, technology is very much a part of all of our lives. Americans, it seems, have always particularly valued the application of new learning in ways that help with the everyday activities and responsibility of life. These technologies – or tools which apply understanding and knowledge – are, and have been, as apparent in the classrooms as in our homes and offices. From clay tablets and pen and ink, to printed books, chalkboards, and computers, these tools have been used to aid in the educational process.

It is helpful to remind ourselves of the constant and familiar role of technology in our lives because the term has come to mean something quite different today. "Technology," in common usage, refers to the new electronic information processing and sharing tools – from calculators to satellites – which were born with the transistor and micro-chip. More than new gadgets, these technologies are heralds of a revolution likely to change every aspect of life on this planet. Therefore, unlike the chalkboard or printed page, the new technologies do not seem familiar, but may often appear foreign and frightening.

For the purposes of this publication, the term "technology" is used in that latter, more narrow sense: to mean computers, audio-visual technologies, and satellites. We trust, however, that the term will be read in a less disturbing context. Like computers, printed books were also once new, and their advent resulted in profound changes in all aspects of human society – changes which we now regard as beneficial. The discussion which follows is based on the belief that while the changes emanating from the new electronic technologies are no less profound than those resulting from the development of print, neither are they more "dangerous."

A final note about terminology. We have elected to use several common acronyms in the text – SEA (State Education Agency) and LEA (Local Education Agency) – and two computer terms that we believe are commonly used and understood: "hardware" (referring to the physical equipment) and "software" or "courseware" (referring to the instructional programs that govern the machines).

PREFACE

It has many names: the "Third Wave," the "Micro Millennium," the "Computer Revolution," the "Information Revolution." Whatever the title, the changes affecting the world – as the results of radically different technologies – are recognized as profound and comprehensive, on par with the agricultural and industrial revolutions of the past.

Futurists describe a world of floating cities, robots, laser surgery, and space stations; of 100-year life expectancy, electronic cottage industry, and sky painting; of genetic engineering, computer shopping, and weather modification. The predictions are endless, often fantastic and seem to become reality almost daily. Already we have witnessed the first artificial heart, voice-operated computers, and laser technology. The moon landing is ancient history; 6,500 robots are at work in American factories. The future, in fact, is not so very far away.

Of special interest are the forecasts concerning education: home schooling, computerized instruction, satellite communications, life-long "in-and-out" educational patterns – changing expectations, changing roles, changing schools. In short, it is suggested that the universal public education system that forms the backbone of United States industrialized society may not adequately serve the needs of the emerging post-industrial nation. Many believe that the information technologies developing so rapidly are more conducive to flexible, individualized, and decentralized instruction and less appropriate to the standard, centralized systems we now have. Thus, the underlying theme of this publication is a very basic question: What is public education's role in the future?

In the winter and spring of 1983, the Southeastern Regional Council for Educational Improvement conducted a survey – in the form of a letter of inquiry – of state education agencies in the 50 states, the District of Columbia, and the U.S. territories. The survey's purpose was to assess the current roles played by technology in public education, and more particularly, to identify the state-level policies and programs shaping those roles.

The results of that survey are reported in *State-level Policy Initiatives*, Volume I of *Schooling and Technology*. In Volume II, the focus moves to the future – both immediate and longer term – and to the policy issues facing state-level educational leaders as the technology revolution continues its course. Its purpose is twofold: to explore the dimensions of the technological revolution; and to begin the process of identifying key policy questions and options before the education community.

THE NEW EQUATION: STUDENT, TEACHER, UNLIMITED INFORMATION

"The world is about to move on from an era where knowledge comes locked up in devices known as books, knowledge which can only be released once keys to their use have been acquired. In the era it is about to enter, the books will come down from their shelves, unlock and release their contents, and cajole, even beseech, their owners to make use of them."

Christopher Evans
The Micro Millennium

The first two elements of the new educational equation are familiar — or appear so. For they are already being reshaped by the third — unlimited information — whose extraordinary power is even now being realized. Unlimited information — and unlimited access to it — alters the way we perceive things, the way we connect one idea to another, the way we communicate with each other, the fundamental way of experiencing our human existence. Suddenly there is more information — facts, beliefs, theories, knowledge, ideas — than any one person can begin to grasp, and with every passing second that amount of information increases — many times over. At the same time, our ability to transmit information has also increased — though not in proportion with the amount of information itself — to such a degree that we describe this as an age of "information overload," and our communications with words like "mass," "simultaneous," and "instantaneous."

Such profound changes suggest the need for rethinking the role of public education, which is now designed to serve the children — and thus the nation — of an era of limited information and a slower rate of change.

Complicating the picture is that major changes, while close at hand, are still about a generation away. Educators must first prepare students for a world of transition — students who will then become a part of the process of change in active, creative ways. As they strive to do so, educational leaders are faced with an overwhelming array of choices and pressures.

The purpose of this publication is to assist those leaders, whose vision and commitment we depend on to shape the future role and nature of the public schools. Part I concerns the broad context in which decisions are to be made: the impact that technology is having in our society and the implications of those changes for the schools. To describe fully the effect of the technological revolution on education is a much larger task than we will undertake here. Therefore, only two aspects of changing society have been chosen for review: the economic context and the evolving educational process.

Part II narrows the focus on the application of technology in the immediate future. It appears that computer technologies may be immediately useful in solving some of the problems currently before the education community, at the same time providing an opportunity for an easier transit into the computer age.

A somewhat longer range view is taken in Part III. In the next 50 years, if forecasts are to be believed, educational policy makers will face and deal with a number of major policy issues — from staffing to graduation requirements — which will shape 21st century schools. Even now, school leaders throughout the country are addressing these issues, considering options and making choices. In this final section, many of the key issues — as perceived by today's educators and futurists — are examined as the first step in the process of identifying options and making choices.

The open society, the unrestricted access to knowledge, the unplanned and uninhibited association of men for its furtherance — these are what may make a vast, complex, ever growing, ever changing, ever more specialized and expert technological world nevertheless a world of human community.

J. Robert Oppenheimer
Science and the Common Understanding

PART I: THE CONTEXT OF CHANGE

The technological revolution affects all aspects of our lives — social, cultural, political, intellectual, religious, economic, environmental. Two of these — the changing economy and the changing teaching/learning process — stand out as having immediate and profound importance to the education community, and therefore serve as the focal point of this report.

The significance of the changing educational process is obvious. Equally vital, though perhaps less obvious, is the relationship between the economy and education, because of the need to develop what many call this nation's most valuable resource — its human "capital", and because of the need for fiscal resources to support the schools' move into the technological age.

By exploring the impact of technology in these two areas, we hope to provide a foundation of understanding necessary for educational policy makers to address two questions critical to the future of public education:

- *Given the vital relationship between the nation's economic well-being and the quality of its educational capacity, what are the human, financial, and political resources required to bring America's public schools into the next century? Who is to provide them?*
- *Technology will surely transform the teaching/learning process in America's public schools. The question before the education community is "How?" Will the changes be initiated by educators and their constituents, with understanding of educational processes and instructional goals; or will the decisions be abdicated to the commercial and technical interests developing the equipment which is transforming society?*

EMPLOYMENT IN A CHANGING ECONOMY

Preparing young men and women to participate productively in the nation's workforce still remains one of the most important responsibilities assigned to the public schools. For that reason, we have chosen to explore the changing employment picture resulting from technological innovations. An understanding of projected employment patterns also serves an additional purpose. It highlights many of the questions yet to be resolved in this revolutionary era — not by education or business alone, but in creative new partnerships.

The bonds between education and the economic sector of society are not new. They date to the birth of the nation and have grown stronger and more visible as the economy shifted from agricultural employment to manufacturing. As the nation moves from manufacturing to knowledge-based industry, the preparatory and training demands placed on the public schools become still greater, and schools will be held even more accountable.

The social patterns of the industrial era tended to separate institutions and to minimize the opportunities for shared responsibility and problem solving. With the technological revolution, however, new and emerging patterns communication and social priorities have begun to blur the boundaries between institutions and to foster cooperative activity in order to meet mutual goals. As states move to meet the challenge of technology, new and stronger links between schools and the business community are already being forged. Examples of these new partnerships are found in a number of states. Iowa has assigned joint responsibility outright for technical education and computer literacy. In its Nov., 1982 report, the Governor's High Technology Task Force encourages partnerships between commercial and educational systems to strengthen the technical competence of teachers and students, and provides incentives "for business/industry and educational institutions to share high technology equipment and facilities." Similarly, a 1982 New Jersey Executive Order established a Commission on Science and Technology whose responsibilities include determining "the requirements of industry, labor, higher education, and government in undertaking a joint effort to encourage the development of a high technology economy."

The nature of the task facing education and its new partners is only beginning to be understood. The rate of change is and will remain tremendous; and the nature of employment in the future — even the very near future — remains unclear. For what kinds of jobs should students be prepared? For what kind of workplace? What level of training will be required? What does it mean for public education?

JOBS FOR TOMORROW

There are at least two views about the future job market. Not surprisingly, each makes different demands on the schools. Experts such as Robert Reich of Harvard University contend that:

EMPLOYMENT PROJECTIONS, GROWTH and DECLINE
(Averaged from Multiple Sources)

(Employment in thousands)	1980	1990	% chg.
Projected Increase			
Fast-food workers	*806*	*1206*	*+49.6*
Nurses aides	*1175*	*1683*	*+43.2*
Nurses	*1104*	*1542*	*+39.6*
Secretaries	*2469*	*3169*	*+28.3*
Truck drivers	*1696*	*2111*	*+24.4*
Waiters/waitresses	*1711*	*2071*	*+21.0*
Janitors	*2751*	*3257*	*+18.3*
Sales clerks	*2880*	*3362*	*+16.7*
Clerks	*2395*	*2772*	*+15.7*
Cashiers	*1993*	*2046*	*+2.6*
Projected Decrease			
Farm laborers	*1175*	*940*	*−25*
Graduate assistants	*132*	*108*	*−22.2*
Farm operators	*1447*	*1201*	*−20.4*
Shoe machine operators	*65*	*54*	*−20.3*
High school teachers	*1237*	*1064*	*−16.2*
College teachers	*457*	*402*	*−13.6*
Compositors, typesetters	*128*	*115*	*−11.3*
Servants	*478*	*449*	*−6.4*
Clergy	*296*	*287*	*−3.1*
Postal clerks	*316*	*310*	*−1.9*

". . . the economies of the industrial nations are undergoing a profound structural transition from manufacturing to knowledge-based industries. The problem is that the U.S. is not moving quickly enough out of the high-volume, standardized production; other countries (e.g., France, England, West Germany, and Japan) are and will continue to offer competition." —March 1983, Atlantic Monthly

From such statements, followers of one school of thought hypothesize that meeting this national need will require a workforce with increased scientific and mathematical skills. Thus, their projections typically cite a shortage of skilled workers for information/knowledge jobs.

Other futurists and economists suggest that the opposite may be true:

". . . Neither will most new jobs be in high technology occupations, nor will the application of high technology in existing jobs require a vast upgrading of the skills of the American labor force. To the contrary, the expansion of the lowest skill jobs in the American economy will vastly outstrip the growth of high technology ones. And the proliferation of high technology industries and their products is far more likely to reduce the skill requirements for jobs in the U.S. economy than to upgrade them." —Levin and Rumberger — The Educational Implications of High Technology

In the short term, the first view prevails. As the United States strives to retain its leadership in the world economy, the nation can expect an increased demand for workers with considerable math and science skill. That effort to keep pace in a rapidly developing technological world will mean other changes as well. We can expect to see less and less U.S. isolation from other nations, a reality that raises important educational policy and curriculum questions — questions not normally mentioned in the same breath with technology: How do we prepare youngsters to live in an international world? What foreign languages will be considered valuable assets for future workers? What other special "international" skills will be required?

In the long term, a different picture is likely to emerge. Apart from a brief surge of demand as the U.S. attempts to catch up with other nations, the prospect of a large proportion of high-skill jobs appear to be small. Current trends (see Table) indicate that the fastest growing types of jobs, in terms of absolute growth, are the services -- including janitors, sales clerks, waiters and waitresses. (Already, McDonald's Restaurants' employees outnumber those of U.S. Steel.) These service occupations are traditionally lower-paid, relatively low-skill jobs.

A little farther into the future, wholly new job fields are expected to blossom — jobs which will require relatively high levels of skill. These include occupations as robot technicians, genetic engineers, energy and waste technicians, and a significant increase in paraprofessional workers in the fields of law and medicine. Many futurists doubt, however, that these new occupations will fully replace the high-skill manufacturing jobs which will disapper in the wake of technological developments. Robots are expected to eliminate 100,000-150,000 jobs and generate only 30,000-70,000. In fact, according to the Arthur D. Little management consulting firm, 20-25 percent of all manufacturing jobs will be eliminated by automation. Still other industrial jobs will be exported — a trend already underway. General Electric, for example, has created 30,000 jobs overseas while eliminating 25,000 at home. RCA has added 19,000 foreign jobs but reduced its U.S. workforce by 14,000.

It's worth underscoring the ironic prediction that relatively few high-tech jobs will be high-skill jobs. More prevalent, futurists predict, will be jobs at minimum wage demanding less skill than many of today's manufacturing jobs.

CHANGING WORK PATTERNS

In addition to shifting numbers and new job titles, educators should note two other important aspects of change: working patterns and conditions, and the role of work in society. While much is still left to conjecture, futurists predict that tomorrow's workplace will be significantly different from the one we know today. They suggest that work will be more dispersed, often performed in the home; that workers will be more project oriented, coming together to solve individual problems, then moving to form different groupings for other tasks; and that jobs will require greater flexibility, mobility, and self-direction than the assembly line jobs of today.

Additionally, it is predicted that the role of work in our society will undergo a transformation in the next several decades. Some futurists predict that the typical work week — which has decreased gradually during this century — will shrink dramatically by the year 2000, reducing the proportion of time spent in earning a living. The implications of such change for the life-styles of American workers are staggering. For educators, the prospect raises serious questions about preparing young people to use leisure time, about the schools' role in shaping attitudes toward work and developing students' human relations skills, and about continuing life-long educational programs.

JOBS WITH SCHOOLS — CAREERS WITH NEW SHAPES

In general, employment patterns for educators can be expected to mirror broad societal trends. Initially — right now, in fact — there will be a high demand for those with technical skills. Potential math and science teachers are even now being wooed with special pay bonuses and loan plans in order to boost their numbers in the schools. But for others, the picture is decidedly different.

One recent study names college and high school teaching among the ten worst job prospects in the next five years. Declining enrollments and rising costs are the primary reasons. But technological advances add a new element to the supply and demand equation — which is likely to result in the dramatic alteration of school employment patterns by the end of the century.

Alternative "Teachers"

With educational funds in short supply, school leaders are exploring different methods of fulfilling staffing needs. These include the use of computers for one-on-one instruction; cable television and other video technologies; shared responsibility for training with business and industry, and sharing of instructors; greater use of other community resources — such as museums, libraries, and community centers — for everything from access to computer terminals and specialized data to recreation and independent study.

New Organization Patterns

Because of the greater reliance on new technology and the greater opportunity to individualize instruction, futurists predict the end — over time — of the traditional "classroom" teacher. Instead of a fixed group of students — organized by grade level and meeting with a single teacher — predictions see the teacher in more flexible roles. He or she will be an education designer — developing instructional programs for each child that include the use not only of teachers and teacher aides, but of computers, audio-

Those with a bent for forecasting enjoy, among other things, determining where the jobs will be in 1990s and beyond. Writing in the June, 1982 edition of *The Futurist,* Marvin Cetron and Thomas O'Toole offered their views on a dozen new occupations where marketplace demand is expected to be intense in the coming decades:

Energy Technician

Demand of energy specialists will greatly exceed available manpower as new sources of energy become marketable. Work stations will include nuclear power plants; coal, shale and tar sands extraction, processing and distribution; solar systems manufacturing, installation and maintenance; synfuels production; biomass facilities operations, and possibly geothermal and ocean thermal energy conversion operations.

Housing Rehabilitation Technician

The doubling of world population in the next 35 years will intensify housing demand, leading to mass production of modular housing, employing radically new construction techniques and materials. Modular housing will be fabricated with all heating, electric, waste disposal and recycling, and communications systems pre-installed.

Hazardous Waste Management Technician

Decades and billions of dollars may be required to clean up cities, industries, air, land, and water. Tens of thousands of jobs will be added in each area as breeder reactors and coal, shale and tar sands mining and processing reach commercial stages.

Industrial Laser Process Technician

Laser manufacturing equipment and processes (including robotic factories) will replace many of the machine and foundry tools and equipment. The new equipment, processes, and materials will permit attainment of higher production quality and quantity at lower production costs.

Industrial Robot Production Technician

The microprocessor industry will become the third largest industry in the U.S., facilitating extensive use of robots to perform computer-directed "physical" and "mental" functions. Millions of human workers will be displaced. New workers will be needed to insure fail-proof operations of row after row of production robots.

Materials Utilization Technician

Future materials are being engineered and created to replace metals, synthetics, and other production materials not suited for advanced manufacturing technologies. Materials utilization technicians must be trained in working with amorphous and polymer materials and others that may be produced at the molecular level through the process of molecular beam epitaxy, inolving atomic crystal growth. In addition, there will be genetically engineered organic materials. These and other "man-made" materials will substitute for natural-element metals and materials now being depleted.

Genetic Engineering Technician

Genetically engineered materials will greatly improve upon and supersede present organic materials and will also produce beneficial effects upon some inorganic materials processes. These engineered "man-made" materials will find extensive usage in industrial products, pharmaceuticals, and agricultural products.

Holographic Inspection Specialist

Completely automated factories will employ optical fibers for sensing light, temperature, pressures, and dimensions and transmitting this information to optical computers that will compare this data with holographic, three-dimensional images stored in the computer. Substantial numbers of inspectors and quality-control staffs will be replaced.

Bionic-Electronic Technician

Mechanics will be needed to manufacture the actual bionic appendage — arm, leg, hand, foot — while other specialists work on the highly sophisticated extensions of neuro-sensing mental functions (seeing, hearing, feeling, speaking) and brain-wave control.

Battery Technician

These technicians will schedule and perform tests and services for new fuel cells and batteries used in vehicles and stationary operations, including residences. Such fuel cells may be charged and discharged by direct electric inputs from conventional electric distribution systems, by solar cells, and by exotic chemicals generating electricity within the cells.

Paramedic

Needs for paramedics will increase directly with the growth of the population and its aging. In forthcoming megalopolises and high-density residences, emergency medical treatment will be rendered on the spot with televised diagnoses and instruction from remote emergency medical centers. Despite reports of a forthcoming glut of doctors, they and other professional and paramedical specialists will become part of emergency medical teams, traveling in elaborately equipped mobile treatment centers.

Geriatric Social Worker

These workers will be essential for the mental and social care of the nation's aging population. By the year 2000, the birthrate of native-born Americans will merely equal the "replacement rate" — zero population growth. Improvements in food, medicine, and life-extending medical processes will create the need for hundreds of thousands of workers to serve the aged.

visual technologies, community and school resource persons (librarians, volunteers, career counselors) and independent study. Teachers and aides will work with children individually and in groups to provide information, solve specific problems, redirect a course of study, assess progress and identify goals.

Changing Training Priorities

The new emphasis, these forecasts suggest, will be less on subject matter expertise and more on understanding the psychology of the educational process, including mastery of the use and application of technologies to assist education. Needless to say, the implications for training requirements are tremendous.

NEW DEMANDS FOR SCHOOLS

Perhaps the single most striking characteristic of the future employment picture is change – rapid and continual. The foremost challenge for public education is the design of curricula and teaching methods which prepare youngsters to live in such a fast-paced world. Although much remains unclear, certain skills appear imperative. Computer literacy is probably a must, since computers will be a part of virtually every occupational setting. What that term implies is far less clear, and defining it is among the first policy decisions facing the education community.

Americans will also need to be prepared to take change in stride, for it will be a constant part of the work experience. It would appear, therefore, that graduates must not only have a solid base of knowledge, but must be quick, adept learners, flexible, self-motivated, and comfortable with changing information and demands.

There is a final educational role implied by these forecasts – a role that may not necessarily be played by the public schools, but will certainly pose major policy questions for public school educators. That role is employee retraining and continuing education. As a result of recent demographic shifts – the median age has risen from 28 to 30 since 1970 – such new schooling patterns are already emerging. Particularly at the post-secondary level, educational policies and opportunities have been expanded and altered to include many more adults. The trend is likely to continue and to include elementary and secondary schools as well. Retraining will be a by-word of the future employment picture, and continuing education may well be the norm for the 21st Century, as universal education has become in the 20th. Not the least of the key questions to be answered is who will assume responsibility for meeting those continuing education and training needs. Schools? Business and industry? A wholly new partnership between the two?

IN SUMMARY

Americans can anticipate a dramatically altered world of work as the result of technological changes. The process, however, is likely to occur in at least two distinct stages. In the short term, as the U.S. endeavors to keep pace with other technologically advanced nations, the demand for highly skilled technicians is expected to be great.

Once the initial demand is satisfied, however, work patterns are expected to settle out into more stable configurations:

- *The emergence of entirely new jobs related to technology, such as robot technicians and genetic engineers.*
- *For the majority of the work force, there will be a proportionate shift from manufacturing to service occupations.*

The changes will mean a fundamental shift from blue collar to white collar work; from many highly skilled and paid occupations to low-wage, low-skill jobs; and from centralized urban manufacturing centers in the Northeast and Midwest to more decentralized locations in the Sunbelt.

Not only are the numbers and kinds of jobs expected to change, but patterns of work are expected to undergo major shifts as the result of new communications technologies. Chief among these are new patterns of multiple, sequential careers, and more flexible and decentralized workplaces.

For the schools, the changes have significant implications. Even now, new definitions are emerging for "basic" work skills – with profound implications for curricula, standards, and teaching methods. Equally important will be the demand for re-education, since tomorrow's employee will require training not for one lifetime career, but for several careers, each of them subject to rapid change.

THE TEACHING/LEARNING PROCESS

In its recent report, the National Commission on Excellence in Education charged that the schools are being swept away in a "tide of mediocrity," thus endangering "our very future as a Nation and a people." In doing so, the Commission has raised to a position of prominence in the national consciousness the growing concerns of educators about the educational system.

For, in recent years, voices of discontent have been growing, both within and outside the school systems. The public school system, complained one educator, is "135 years old and at least 75 years out of date, [and] day by day and year by year frustrates everybody in it — students, teachers and administrators alike."

Opinions differ widely on how to solve the problems of schools. For some, the solution is to be found in a return to "basics," more rigor and fewer "frills." Others have proposed innovations ranging from ungraded and decentralized schools to new curricula.

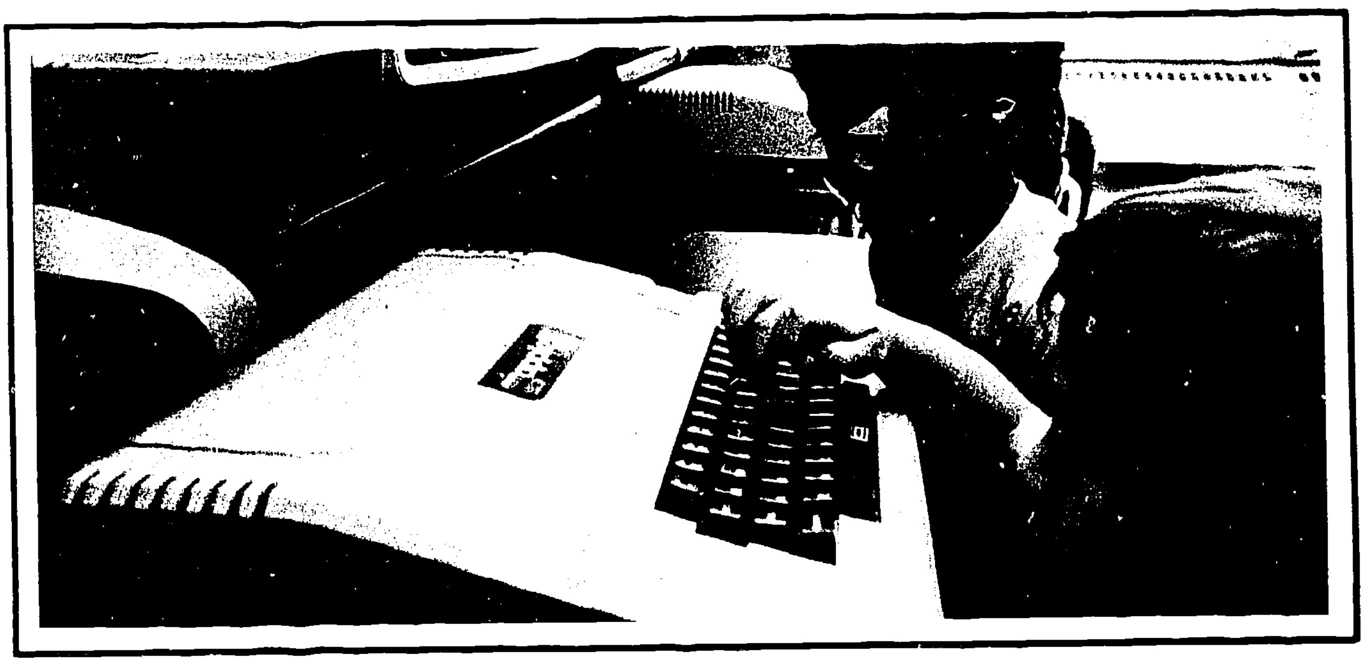
Those with an eye to the rapid change occuring in society take a somewhat different — and decidedly more optimistic — view. The schools are evolving, they point out, not sedately, but explosively. Therefore, criticism of the schools' "failings" miss the point, because the standards for judging schools are themselves changing. What is called for is not a debate on the relative merits of methodology, but a fundamental reassessment of the purposes of schooling. Above everything, they say, is that the technological revolution offers educators tremendous opportunity for solving problems and reaching goals.

One thing on which learning theorists seem to agree is that learning is an individual process. Despite some general similarities, it varies from person to person, year to year, subject to subject. Unfortunately, it is quite difficult to design a single system that — even at the local district level — can provide all children with individualized instruction. In fact, public school systems in this country are not designed to do so. They are, instead, shaped to meet social and economic needs rather than to fulfill theories of learning. And it may be reasonably argued that since the nation's primary goal is universal education, not individualized instruction, the current system is the most efficient means of reaching that goal.

Furthermore, contemporary school systems are also the most efficient means of teaching what futurist Alvin Toffler calls the "covert curriculum" of industrial society:

> *"It consisted — and still does in most industrial nations — of three courses: one in punctuality, one in obedience, and one in rote, repetitive work. Factory labor demanded workers who showed up on time, especially assembly-line hands. It demanded workers who would take orders from a management hierarchy without questioning. And it demanded men and women prepared to slave away at machines or in offices, performing brutally repetitious operations."*

But the nature of the workplace, the required skills of the labor force, and ultimately the goals of the schools are changing. If the ideal citizen and worker of the future will be flexible, self-motivated, and an adept learner, the ideal educational program will stress flexibility and be highly individualized — a model of schooling that is far more consistent with learning theory than is presently the case. Therein lie the roots of a growing optimism and enthusiasm in the education community. In the new technological age, the goals of the schools, and the new educational tools offer the opportunity for school systems to provide education in its most basic and best form: individually paced and designed.



COMMENTS FROM RESEARCHERS AND OTHER INTERESTED PARTIES

In reviewing the literature for this publication, a series of facts, figures, observations, comments and conclusions caught our attention. They are offered in this summary way:

- *IBM expects to sell one million personal computers by the end of 1984 — and has added 500 employees for assembly tasks.*
- *TIMEX is now manufacturing their $100 computer at the rate of one every 10 seconds. It will be marketed in over 100,000 outlets — with predictions that one million will be sold by the end of 1984.*
- *Researchers say the evidence is clear: use of technology, especially computer-based, produces a significant gain in student learning — true for both high- and low-aptitude students. And, researchers agree, students using computers tend to become more interested in the subject matter, and learn more quickly than by conventional teaching methods.*
- *The attraction of computer games will probably force educators to use game formats more in educational materials.*
- *Children who are excellent at programming are also likely to be good at mathematics or science.*
- *Computers increase, rather than decrease, socialization among children.*
- *Britain will pay one-half the cost of computers for elementary schools.*
- *A Robot "Butler" was built in 1983, and three were sold by Neiman-Marcus at $15,000 each. The developer is now working on a kit that will sell for less than $2,000.*
- *Computer literacy will be required of all students at Pepperdine University by 1984. Beginning in the fall of 1983, freshmen at Stevens Institute of Technology must have computers if they plan to study science or systems planning and management.*
- *Researchers also agree that at present we know relatively little about how to individualize instruction for students, and do not yet have a good understanding of the effects of instructional variables such as graphics, speech, motion, or humor.*

THE COMPUTER AS INSTRUCTIONAL TOOL

Although computers are still relatively new in the classroom, the connection is natural. From the beginning, they have been used as thinking, learning and problem-solving tools. Their basic purpose has been to facilitate these human processes with their superhuman speed and accuracy — first as number crunchers and data processors, then through simulations, and more recently through sophisticated problem-solving programs.

Early research on the use of computers as teaching tools indicates that they are highly effective, efficient means for providing instruction. Studies (see Table) have shown that computer assisted instruction (CAI, in common usage) produces significant gains in student learning; students tend to become more interested in subject matter; and, most important, can do the job more quickly than conventional methods.

Despite their seemingly limitless potential, computers are not without controversy. Critics are concerned about their misuse — as expensive "page turners" — and about inflated expectations. Some educators fear computers will foster laziness and lead to deterioration of basic skills. The lack of human contact worries some; they argue that bringing computers into the schools will be dehumanizing. Others are simply cautious, withholding judgment — and enthusiasm — until further study is done.

In the last analysis, however, supporters outweigh detractors — 86 percent of the teachers responding in one recent survey indicated a high level of interest in computers and perceived the same of others in their schools. The future of computer use in the schools looks very bright indeed.

MATCHING MEDIUM AND METHOD

While computers unquestionably have a starring role among the new educational technologies, they are not alone, nor are they without limitations. In that statement is the crux of a critical issue facing educators: What is the appropriate use of the new technologies?

It is not an easy question, and many educators hesitate to adopt new technological tools because the answer is unclear. A number recall — none too happily — the recent and less than successful experiments with instructional television. The television analogy may be an instructive one, because although not much is known about how to use some of the newest technologies, a great deal has been learned about effective and ineffective uses of televison.

Research indicates that television was (and is) used in traditional ways simply to convey information. The problem, says educational media expert Anthony Prete, is that "television is primarily an impact medium and not an information medium." An infomation medium — such as a dictionary — is designed to convey information. An impact medium, says Prete, appeals to the emotions; it can be a very effective educational tool — one which motivates students to further study, conveys important messages, or involves them in the exploration of art.

Although the lesson seems simple – identify the strengths of a particular instructional tool, and use those strengths to attain various educational goals – the applications of that lesson are not. Many of the new educational technologies – video discs, computers, even calculators – are still relatively unknown quantities insofar as their educational capacities and strengths are concerned. Thus, the education community will require opportunities for study and experimentation. Designing and financing these opportunities is no small challenge.

EXPANDED OPPORTUNITIES – CHANGING PARAMETERS OF EDUCATION

The new information technologies open a great many doors. Potentially, they offer every school – regardless of size – superior library and research materials; every student individually paced and designed instruction. They free teachers from routine activities like marking and recording grades or monitoring normal work periods. They can reduce the costs and difficulty of maintaining records and managing schools, transportation, and food systems. They help link schools with other institutions, including private businesses, museums, government agencies. They make available, through a variety of networks, artistic and cultural experiences, new research, entertainment.

What is also true is that they invite change. The extensive use of the opportunities afforded by computers, satellites, television, and telephone tends to modify the traditional model of the self-contained school. As the model changes so will notions about home and independent study, internships, teaching and competency standards, and curriculum requirements. In fact, many such terms may require new definitions. Among the challenges facing educators in the decades ahead is to reassess and redefine beliefs about what constitute basic skills and competencies, even the meaning of intelligence.

IN SUMMARY

America's public education system is undergoing a period of revolutionary change – reflected in controversy over goals, methods, and standards. At the heart of the revolution is the computer, which is transforming not only the social and economic context of public schooling, but the teaching/learning process itself.

Through technology, futurists predict, educators can look forward to individualized instruction for all students, faster, more efficient instructional programs, and expanded learning opportunities for all ages in all areas.

To realize that potential, educators must address several key issues:

- *A rethinking of fundamental goals and schooling policies is required, and a reshaping of educational programs and standards.*
- *The educational possibilities of the new technologies are, at present, largely untested. Much research is required to realize their potential.*
- *One of the greatest challenges ahead is to train the educational work force to use the new technologies effectively.*

PART II: SOLVING OLD PROBLEMS IN NEW WAYS

Happily, the first steps into the future world of education may be taken immediately and simply. Put another way, there is a long list of existing educational problems whose immediate solution may be found in the new technologies. That process has already begun.

Teacher Shortages: One of the most visible problems currently afflicting public education is the shortage of math and science teachers. The combination of dwindling numbers of qualified teachers, more attractive work opportunities in the private sector, and the simultaneous emphasis on strong math and science skills have created a crisis of sorts. It is estimated that there are 21% fewer math teachers than are required nationwide. Salaries for math and science teachers average just over $17,000; entry salaries for those with comparable skills in the private sector average $23,000 to $31,000 per year. Like the dilemmas related to employment, the problem is ironic. At the time when demand and interest in the subjects is highest, the resources are the least.

Although the shortage is real, some argue that the problem may be exaggerated. The lengthy and costly process of training and attracting qualified teachers may not be the only answer.

South Carolina is one state where technology has been used to make up for insufficient numbers of math and science teachers. "Instructional television," the South Carolina SEA reports, "and other similar aids are growing in importance among the array of options used to transmit critical math and science knowledge to students in the public schools." Other suggested approaches include the use of computers to assume much of the "teaching" responsibility for basic skills drills and practice, freeing the limited numbers of math and science teachers to reach more students and provide more advanced instruction.

Limited Curricula in Small, Rural School Districts: Through satellites, computers, and cable and other television technologies, students in small, rural school systems may gain access to a broader curriculum. Alaska offers an excellent example of the use of such technologies to overcome geographic and climactic barriers. There, one- and two-teacher schools are afforded complete instructional programs via satellite and computer. The technologies not only provide access to instruction, but to libraries and other data banks.

Especially Difficult Courses: The new technologies can be a special boon to teachers. Courses such as physics, chemistry, grammar, foreign languages, and advanced math that require more intensive study can be offered, in part or in whole, by computers and video technology. Furthermore, they may be offered when there is little qualified teacher time and only small interest. One student could pursue French through the fifth or sixth year, for example, with minimal teacher participation, and without affecting other students' learning opportunities or time.

Differences in Quality Between Rich and Poor Districts: For years, the issue of financial equity between wealthy and poor school systems has claimed the attention — and energy — of educators across the country. Efforts to equalize educational opportunities — including resources, materials, staff, and curricular offerings — have involved court orders, legislation, complex plans and programs, and millions of dollars.

Educational technologies may offer a way of equalizing many school resources far more simply at far less cost. Satellites, computers and television technologies offer the possibility of linking poorer districts to the best in library and reference resources; expanding course offerings; increasing one-on-one instruction, tutorial assistance, and special education programs; providing sophisticad educational and career counseling, and adult and continuing education programs; improving administrative support and inservice training.

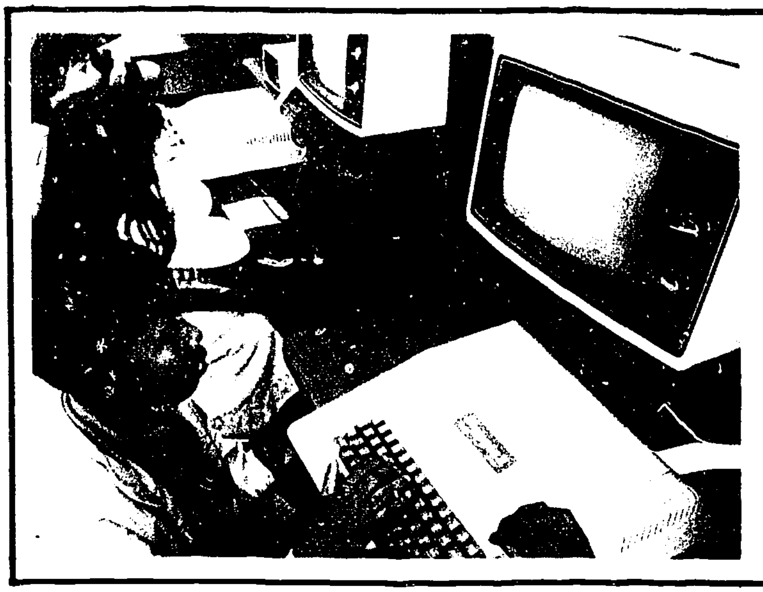
Problems With Basic Skills: Computers can be especially effective, researchers say, in providing the intensive repetition necessary to develop strong basic skills. Arithmetic, grammar, spelling, computation, and other basic skills are strengthened through drills with immediate and continual feedback. Similarly, computers can be used effectively in developing analytical and problem-solving skills, by setting up problems in sequence for students to solve, and through simulations.

Communications Between SEAs and Local Districts: A number of states, including Ohio and Minnesota, have computerized reporting requirements, thereby speeding up data collection and transmission, improving the consistency and reliability of information, accelerating budgeting and funding allocation processes, and generally easing the paperwork burden in the local districts. Electronic mail and other techniques enhance communications in many states.

IN SUMMARY

Already the process of change has begun, as educators employ new technologies to solve existing educational and administrative problems. Among the immediate applications of the new technology are:

- *Providing instruction in important subjects where there are shortages of teachers.*
- *Providing expanded curricular offerings in small and rural districts.*
- *Equalizing educational opportunities between wealthy and poor districts.*
- *Improving communications and data reporting between SEAs and local districts.*
- *Enhancing instruction in especially difficult courses.*
- *Expanding opportunities for advanced study.*



No one knows in detail what the future holds, or what will work best in a Third Wave society. For this reason, we should think not of a single massive reorganization or of a single revolutionary, cataclysmic change imposed from the top, but of thousands of conscious, decentralized experiments that permit us to test new models of political decision-making at local and regional levels in advance of their application to the national and transnational levels.

Alvin Toffler
The Third Wave

PART III: POLICY QUESTIONS AND OPTIONS

Even as they aid the educational process, the new technologies will be reshaping it, as will the individual and collective decisions of educational policy makers and practitioners. Those decisions are already being made. To their credit, educators throughout the country recognize the importance of the social changes brought on by technology and are moving to address many of the questions raised.

But the process of change is neither simple nor orderly. The range of options facing educators is staggering as is the speed of the technological change. Questions about what equipment to use and how to use it – difficult as they are – pale in comparison to questions about the changing purposes of schools and roles of educators.

Four major concerns are examined in this section, for two purposes: to describe the dimensions of each, and to begin the process of identifying the key questions and policy options which will be facing educators in the months and years immediately ahead.

CURRICULUM

BASIC SKILLS FOR THE FUTURE

Some would argue that the phrase "back to basics" is a contradiction in terms – or at least that it misses the point. Going "back" in pursuit of basic skills may be completely inappropriate, since what was once basic and what is becoming basic might be two different things. Contemporary American youngsters, one writer says, are "not very much like 1903 kids . . . The new learner, who is the product of this all-at-once electronic environment, often feels out of it in a linear, one-thing-at-a-time environment."

In defining the basics for that new breed of child, educators will need to consider:

- *Existing staffing patterns, which tend to compartmentalize instruction by subject matter.*
- *Standards for assessing basic skills competencies – both for "old" and "new" skills.*
- *Training requirements for preparing staff to teach the new curriculum.*

CONTENT V. PROCESS

"We can no longer teach [students] all about a subject; we can teach them what a subject is all about." Thus educational media specialist John Culkin summed up one of the key problems of what Marshall McLuhan called an age of "information overload." With knowledge expanding by geometric stages, the emphasis on teaching content is no longer practical, even if it were desirable. And many argue that it is not. "To help kids learn in this age," Culkin said, "we have to . . . teach them to be their own data processors." Therefore, the computer is not only the vehicle for future education, it is the model.

A critical concern to educators is if, when, and how to shift from an emphasis on content to one on process. The issue directly affects decisions about curriculum design, graduation and promotion requirements, teacher training, and the use of computers. A number of questions are raised:

- *At what age does the focus appropriately shift from learning information to learning how to use it and where to find it?*
- *Are there some subjects where content is vital or more important than process?*
- *How do you define basic skills in terms of content and process?*
- *Who makes the choices?*

INDIVIDUALIZING INSTRUCTION

Although individualized instruction — curriculum, pace, evaluation tailored to each child — has long been a goal of educators, it has remained largely out of reach. Instead, priority has been assigned to "universal" schooling, and school schedules, curricula, staffing patterns, and standards have been adjusted accordingly. Technology offers the opportunity, supporters say, to do both: individualize instruction for all.

With the opportunity come challenges:

- *How is a standard curriculum adapted to meet individual needs?*
- *How is such individualization reconciled with graduation requirements and promotion standards?*
- *With grade levels or standardized tests?*

Prior experiments with ungraded schools, team instruction, and independent study, as well as extensive experience with special education programs for the handicapped, gifted, and talented, may serve as models for individualized programs in the future. Interestingly, these are among the first programs — in states like Missouri, Montana and Florida — to take advantage of the new technology. Missouri has funded the development of an automated system for IEPs (Individualized Education Plan) in two local districts. Montana has used computer technology in programs for the deaf and blind and bilingual students. Florida's Bureau of Education for Exceptional Children supports a number of projects for technical applications in exceptional student education. Additionally, a number of states — including Delaware, Ohio and Pennsylvania — use the new technology for tracking students and managing special education programs and records.

Even these innovative programs, however, remain within the context of standard curricula and standard goals and objectives. Thus, difficult questions remain:

- *What does an "individualized" school look like?*
- *How are standards to be set and for what purpose?*
- *What will be the roles of teachers, administrators and counselors, evaluators, and media specialists in a world of individualized instruction?*

CHANGING INSTRUCTIONAL PHILOSOPHIES AND STRATEGIES

A video disc hooked to a computer takes an elementary class to the Louvre, where they wander at will from gallery to gallery, observing various works of art from different angles.

Medical students today can take a course that could never have been offered in the past and acquire skills that might otherwise take years to develop. Computer reproductions of the sound of heart-beats — depicting a full range of heart diseases and problems — accompany visual and textual information about heart disorders and their symptoms. Without spending many hours traveling from patient to patient, students could not otherwise become aurally familiar with heart problems.

These examples raise fundamental questions about current beliefs and expectations of the educational process. Perceptions about the limits of curriculum are changing. Educator Seymour Papert, author of the computer language LOGO, points out that computers can graphically show concepts that, in the past, could only be taught with words.

Theories of physics and other sciences, for example, become accessible to much younger children because they can now be represented concretely, Papert says. Thus, commonly held beliefs about sequence and learning pace are subject to change.

For policy makers, questions raised include:

- *What are the new learning opportunities to be gained from technology? How are they identified?*
- *What opportunities are available to staff at local and state levels to conduct research investigating technological potential?*
- *How often and in what manner are curricular philosophies and programs examined? By whom?*
- *How much flexibility is there — in curriculum requirements, performance standards, staff policies — to permit experimentation with new technologies and ideas?*

DEFINING COMPUTER LITERACY

A great many educators and others appear to agree that "computer literacy" is an important — if not essential — skill for all students if they are to function successfully in future society. At least 26 states support the concept of computer literacy. For the most part, however, the support is general and non-prescriptive. Recommendations "encourage access to computer literacy for all children," or direct districts to "promote computer literacy through various of the disciplines." Only two states specifically require computer literacy of students; only half a dozen have specific requirements of staff.

Even more vague is the term itself. Only a few states, as yet, have developed a definition for computer literacy, although several others are in the process of doing so. Some have left the task to local districts. The definitions that do exist are general and not tied to specific performance requirements. They include such elements as "definitions of computer terms," "familiarity with basic components of the microcomputer," "understanding the ethical/moral implications of technology in society," and "identifying popular computer programming languages and their areas of application."

The common approach for defining computer literacy for staff is to establish certification requirements.

POLICY ISSUES

CURRICULUM

Defining Computer Literacy
Identifying "Basic" Skills for the Future
Providing Individualized Instruction
Moving from Emphasis on Content to Emphasis on Process
Changing Instructional Philosophies and Strategies
Determining Responsibility for Teaching

EQUIPMENT

Sharing Information
Courseware Creation and Selection
Keeping Abreast of Changing Technologies

STAFF

Defining Computer Literacy for Teachers
Acquiring Technological Competencies — Training
Rising Expectations for and of Teachers
Shifting Work Patterns
External "Teachers" — Using Expanding Educational Resources

FINANCE

Setting Priorities
New Options
Equity

POLICY ARENAS

CURRICULUM

Curriculum Requirements — Subject Areas, Sequence
Graduation and Promotion Requirements
Testing Practices and Policies
Statewide Educational Goals
Teacher Training Institutions and Certification Processes

EQUIPMENT

Approval Processes for Instructional Materials
Purchasing Policies and Practices

STAFF

Certification Requirements
Policies Related to Tenure, Promotion, Salaries
Approval of Teacher Training Institutions
Inservice and Retraining Policies, Requirements, Programs

FINANCE

Budgets
State Goals and Plans — Priorities
Contract Negotiations
Legislative and Regulatory Mandates for: Teacher-Pupil Ratios, Certification Requirements

South Dakota for example, requires that a "teacher instructing a course in computer programming or hardware lasting nine weeks or longer shall have a minimum of eight semester hours in computer-related courses, including at least four . . . in programming language and two . . . in fundamentals of computer systems."

As broad as the support is for the idea of computer literacy, relatively few states have endorsed its inclusion in the curriculum. Fewer still require it. Instead, most promote the accessibility of such course offerings. Arizona is among several states permitting the completion of a computer course to fulfill a math requirement.

In deciding how to define the term and what importance to attach to it, education policy makers might consider the following:

- *The degree to which such skills will be required in the workplace. Current estimates indicate that shortly over one half of all jobs will be related to information processing and that virtually all workers will come in contact with computer technology. The level of computer skills required, however, is still hotly debated.*
- *Advances in technology. Forecasters predict that computers will be voice-activated, will diagnose their own problems and prescribe their own repair, and can be programmed in the user's language. Many suggest that the average user will not need special training any more than today's average driver needs a knowledge of auto mechanics. At the same time, the need for understanding the applications of computers – for solving, computation, and communications – may be greater than ever.*
- *The value of the computer as a learning tool. Many advocates of computer use see computer literacy as an important course of study – regardless of the level of skill needed to function in society. They point to the skills acquired in the process of learning to use computers: problem solving, logic, critical thinking, and even creativity. In fact, some suggest that computers may offer one of the most effective ways of teaching these skills.*

CURRICULAR RESPONSIBILITY

A common prediction among futurists – and future looking educators – is that much vocational training will be done by business and industry. The degree of specialization required and the rapid rate of change in the work world, the argument goes, make the public schools an impractical choice for technical training. Similarly, many question whether such programs as driver education or sex education should be the responsibility of the schools. In short, a major issue is not just what will be taught, but who will teach it.

While the question is not new, the context is. Technological advances are drastically altering the nature of vocational training, are making possible broad access – via television and computer – to independent study, and are creating a large and rapidly growing commercial educational market.

Considerations for the educational community include:

- *identifying the most effective ways of meeting various educational and training needs.*
- *funding jointly sponsored programs*
- *setting competency standards – for students and staff appropriate to decentralized and shared schooling responsibilities.*

EQUIPMENT

The term "equipment" refers to both hardware and, of greater concern to educators, software or courseware.

The questions it raises are familiar: Which computer? How many do we need? How often must we upgrade? What courseware? Who selects it? Who evaluates it? How is it best used? Perhaps the most important question is: To what extent is courseware development related to educational uses and needs?

SHARING INFORMATION

Judging from the survey responses, the primary role assumed by SEAs is to provide information so that local district educators may make informed decisions about what to buy, what to use, and how to use it. At least 29 states have established some form of information center, laboratory or clearinghouse, or support regional consortia that offer such services. Washington and Minnesota have published handbooks describing available options and applications of the technology; a number of other states provide bibliographies. Illinois operates lending libraries through its regional consortia which permit local districts to try out equipment and software before making final choices.

Several states – including Alabama, Florida and the District of Columbia – have set up laboratories to provide local and state-level educators facilities for thorough review, and in some cases, testing of computer equipment and courseware.

Despite the high level of activity, questions remain related to how information is shared.

- *Does the use of a clearinghouse tend to replace any direct involvement in the process of developing courseware?*
- *Are there sufficient opportunities for thorough evaluation?*
- *How do networks, clearinghouses, and review processes encourage or inhibit local experimentation?*
- *How may the technology itself be used to share information? Both Kentucky and South Carolina use statewide television educational systems to provide LEAs with inservice training on computer use and other information related to the new technology.*

COURSEWARE CREATION AND SELECTION

A common concern expressed by educators is the shortage of quality courseware. Because of the high costs of initial development and the low profitability of the education market, there is relatively little software available for instructional purposes, and it is a mixed bag. Educators complain that few programs are developed with an understanding of the learning process.

Of all the issues confronting educational policy makers, this may be the most difficult. Two kinds of issues are raised – those relating to the development of educational software and those relating to its selection and approval.

A number of states have developed their own software programs for administrative and student accounting purposes, although most assume no role in creating instructional materials for computers. Minnesota's consortium – MECC – is a notable exception. Instead, SEAs and regional centers play an intermediate role, reviewing, evaluating, and sometimes approving materials for LEA use. As a consequence, to date, educators' contribution to the supply of courseware has been minimal.

If educators are not writing their own courseware – and there is no strong movement in favor of that approach – who is, and what do these writers know about education? More to the point of this discussion, what is the role of educators, particularly at the state level, in working with commercial software developers to ensure that courseware is educationally valid and meets the needs of school programs?

To date, it appears that educators' contribution to the development process is almost entirely at the discretion of commercial producers. The commonly held opinion is that that presence is minimal.

The importance of this issue lies in the nature of the technology. Although handled in some areas much like a textbook, computer software is a distinctly different instructional tool. In contrast to textbooks – which are non-interactive and perform a specific supplemental function in a given course of study – computers are interactive, and may serve in a parallel capacity to the teacher. Courseware should therefore be developed – as a teacher's instructional plan is developed – with an understanding of the learning process. Thus, the programmer is required to have expertise not only in a given subject matter, but in the educational process – a level of expertise not required of the textbook author.

The development of sequential courseware provokes additional questions:

- *How can it be developed so that it is consistent with curriculum objectives?*
- *How does it fit into other instructional programs?*

In short, the lack of professional educational involvement in the development of computer courseware raises serious questions about who will be shaping tomorrow's curriculum.

Closely related is the issue of courseware selection. The common approach, judging from survey respondents, is to handle the process just as textbook selection is handled. Utah, in fact, specifically assigns responsibility for courseware approval to the state's normal textbook approval process. Thus it can be anticipated that the selection of instructional technologies will be plagued by many of the problems related to textbook selection: insufficient participation by trained educators or public representatives; political and financial considerations taking precedence over educational ones; statewide rather than individualized or even "localized" instruction; and limited flexibility.

Two related issues deserve brief mention:

- Coordination of software and hardware. Although the two obviously go together, traditional selection processes do not always coordinate so efficiently. Policy makers should consider whether equipment approval and purchasing policies are consistent with software selection and approval.
- "Generation Gap." It is an intriguing problem. Its only solution may be a generation's time. The software being developed today and the educational applications of that software are the creation of industrial-age thinkers. The "clients" are electronic-age children. That is important to policy makers for two reasons:

(1) The effectiveness of educational applications of technology is affected by that "generation gap." Thus, judgments about its efficacy may be flawed. Since such judgments affect decisions about whether or not to use technologies, they should be viewed in this context.

(2) Research about the effectiveness of the technology may not take sufficient note of the opinions of our space-age generation. To the extent that state leaders shape the nature of research and experimentation, the generation gap deserves their consideration.

KEEPING UP

One of the greatest frustrations of our electronic revolution is that it is hard to keep pace with new developments. No sooner is the decision made about what equipment to purchase, than a newer model hits the market. It is especially challenging for democratically governed, bureaucratic, centralized institutions to keep up with the changing technology, its constantly emerging applications and the latest research.

A few considerations include:

- *How flexible are purchasing policies? Do they permit varied local choices? Are leases permitted in lieu of purchase?*
- *Is equipment purchased as capital expenditures or as supplies? How do those choices limit or enhance curriculum options? Research? Flexibility?*
- *What about donations of shared equipment?*
- *What mechanisms are in place to monitor research and share information with local districts?*
- *Are purchasing agents and educational planners partners in decisions about technology purchases?*

Issues related to staffing and technology might be summed up in the word "training" — or, more accurately, "retraining." Teachers are, even now, expected to understand and use the new technology in instructional settings and to act on new theories of learning and teaching. For those fresh out of school, with no models to observe, the task is difficult enough. For those who are products of and committed to traditional theories and practices, the change can be devastating.

The issues related to staff training/education are complex and often highly political, posing a special challenge to those who make policy.

DEFINING "COMPUTER LITERACY" FOR TEACHERS

If a definition of computer literacy for students is hard to find, it is doubly elusive when applied to teachers. Presumably, teachers would need the same kind of "literacy" as students, but that may not be enough. If computers and other technologies are to play a major role throughout the curriculum, it follows that teachers will require a sophisticated level of understanding of how to use each medium. Furthermore, some teachers would require advanced skills in order to teach students advanced computer capabilities.

Although many states support or require computer literacy for staff, few specify the kinds of skills expected of them. The District of Columbia has the most sweeping requirements: "computer literacy and software selection skills . . . for all instructional personnel (teachers, supervisors, and administrators) as part of the five-year recertification requirements," and "beginning with school year 1983-84, all new teachers would have to demonstrate computer literacy before being granted permanent tenure."

In other states — including South Dakota, Illinois and Vermont — the decision has been made to adjust or expand certification guidelines or requirements for teaching computer courses, a pattern consistent with schools' current emphasis on subject matter over process. In most states, however, computer literacy and teachers' computer skills are undefined.

Related training issues to be addressed include:

- *Using technology appropriately and creatively. Fears have been expressed that the new computer — used improperly — will add little to the educational program but expense. Experts agree that if all staff are well trained in the various uses of equipment, technology can offer a great deal.*
- *Overcoming biases and fears. A recent university survey found that only three percent of K-12 teachers in one state felt confident that they knew how to use a computer. Frustration and resistance to the new technology are compounded when students familiar with the equipment are significantly more skilled than their teachers. But lack of familiarity is not the only concern. Many teachers see computers as threats to their jobs and to strongly held beliefs about "correct" schooling methods.*
- *Training teachers to use new teaching equipment in ways that reflect new goals, shapes and styles of education. In short, there will be a need to re-shape teachers' perceptions of educational goals, structures, and processes.*

ACQUIRING COMPETENCIES

Defining the "computer literate teacher" is only half the battle — perhaps the easier half. Fortunately, a massive retraining effort is already underway. Inservice training through workshops and conferences — at state, regional, and local levels — is perhaps the most prevalent state-level activity in support of educational technology. Virtually all states are engaged in some form of inservice training, ranging from workshops on microcomputers and software writing skills to the broadcasting of training programs over instructional television channels.

The big questions concern the kind of training. Because of the knowledge explosion, the emphasis in schooling is likely to shift from subject matter to learning and thinking skills. For teachers, the same kind of shift is necessary. While today's teacher training institutions emphasize expertise in given subject areas — with educational training added on — the focus in the future is likely to be on the educational process, with skill building in the use of instructional technologies and lesser emphasis on given subject areas.

Important considerations for policy makers include:

- *Revising certification requirements to reflect the changing training needs of teachers.*
- *Particularly in the short term, providing school staff special opportunities — both preservice and inservice — for developing technological skills.*
- *Providing inservice and preservice training programs which reflect the shift from emphasis on subject area to emphasis on learning process.*

RISING EXPECTATIONS

In its recent report on American education, the National Commission on Excellence in Education called the quality of teaching inadequate and recommended, among other things, higher academic standards for teachers, professionally competitive salaries, and longer contracts. In short, said the Commission, Americans expect more from their public school teachers and should be willing to match expectations with compensation.

What the report did not say, but appears to be increasingly true, is that teachers are expected to acquire a whole new range of skills as we move into the computer age. Thus, the expectations of policy makers must also rise. Teachers asked to do more and better can (and do) expect adequate training and retraining opportunities as well as adequate salaries.

For legislators and educational leaders, the need to match new demands of teachers with appropriate resources and training opportunities poses special political and fiscal challenges:

- *Designing inservice programs to give existing staff opportunities to improve skills and develop technological competencies;*
- *Coordinating preservice and inservice training programs;*
- *Finding the additional funds necessary to support better qualified staff.*

SHIFTING WORK PATTERNS

Terms like "merit pay," "differentiated staffing," and "master teacher" pack a powerful political charge these days. They are part of the technological revolution and will demand consideration.

In the opinion of a growing number of educators and others, the days of the traditional classroom are numbered and with the classroom go contemporary staffing patterns, including departmental hierarchies and the role of tenure. Some educators project patterns which include flexible teams of master teachers, aides and apprentices, and computers — working with varying sized groups of students to meet curricular goals.

A few state level policy leaders are considering formal policies in these areas — notably Tennessee's Governor Lamar Alexander, whose controversial "master teacher plan" has earned national attention, if not statewide approval. On more informal levels, the topics are the subject of considerable interest and discussion and can be expected to play a major role in the policy decisions of the coming decade.

Among the challenges are:

- *Setting training and competency standards for "master teacher" status.*
- *Retraining existing staff and adapting existing school organization to make effective use of technologies.*
- *Reshaping collective bargaining contracts and state labor laws to reflect the proposed new uses and organization of teaching staff.*

OUTSIDE "TEACHERS"

Today, computer data bases are being sold by some 240 outlets (55 more than a year ago) and there are an estimated 1,600 public access data banks in 275 subject areas. Cable television offers tremendous opportunities for public accessible instruction; and we have only seen the beginning. As more and more schools hook up electronically to more and more informational and instructional networks, several important questions are raised:

- *Who is in charge of these outside "teachers"?*
- *Are these "teachers" supplemental or integral parts of a school's staff?*
- *How are they used?*
- *Who makes the decisions?*

FINANCE

Computers and other electronic technologies are not inexpensive. As an immediate problem in a time of economic constraint and dwindling federal support for education, this may rank as the most pressing issue of the day.

It is also an area where a great deal of ingenuity has yielded a great deal of success. Joint purchasing programs, matching grants, tax incentives, and out-and-out wheeling and dealing have helped to furnish classrooms across the country with — based on most recent estimates — about 175,000 computers for instructional use. That doesn't include the thousands of computers used for school administrative purposes and by SEAs.

A good number of states have some form of group purchasing arrangement — either at the state level or through regional and interstate consortia such as Project MECC. Virginia and Indiana are among those who have adopted legislation offering tax incentives to businesses donating computers to schools. Iowa recommends such incentives as does Louisiana. Several states, including Ohio and Alaska, have appropriated funds sufficient to establish statewide computing and communictations networks. And it is likely that numerous local districts — like Lexington, Mass. — have independently found ways to fund their participation in the computer revolution — by soliciting donations from parents and local industry and by using available federal discretionary funds.

State funds are used for a variety of purposes — from the matching of local monies for the purchase of equipment, to support for research, and the establishment of statewide laboratories and communications networks. Sharing is another method used widely to stretch scarce technology dollars. Through consortia, lending libraries, and other regional approaches, districts are provided access to equipment and training.

Among the issues related to the funding of educational technology:

SETTING PRIORITIES

There are few "extra" educational dollars anywhere. More likely, schools will continue to see budget cuts, even while demands increase. Therefore, the question about where to put scarce dollars is a key one. Dozens of different responses have already been made. In some states, funds support the creation of statewide networks or consortia. Other states have invested in instructional televison or equipment purchased for local districts.

Although the most activity is reported in the area of inservice training, the fewest dollars have been appropriated specifically for that purpose. Funding for research and evaluation of technologies is rare. Those patterns may shift, however, as more and more school systems acquire basic equipment.

But that is only one aspect of the "where to put the money" question. Choices must also be made about what portion – if any – of state budgets is to be earmarked for new educational technology and its related training demands.

Choices among different kinds of equipment, between equipment and training needs, between additional staff and additional equipment are difficult. In setting priorities, policy makers will need to consider the following:

- *The relationship between a healthy economy and quality schooling is a vital one. Thus, investment in education is of critical importance to the nation.*
- *Teachers are and will remain the key ingredient in the educational process and in the schools' economic equation. As such, costs of adequate training and compensation warrant high priority.*
- *As great as technology's educational potential appears, it remains largely untested. The process of testing and experimenting with the new technology is costly, yet essential to the educational community. Furthermore, it may yield important cost-saving applications of the technology. For these reasons, such investments also deserve high priority.*

NEW OPTIONS

The technological revolution brings not only new fiscal demands, but new opportunities and some entirely new policy questions. The ever-increasing costs of transportation and energy are of imperative concern. Furthermore, with rising energy costs and calls for longer school days and terms, the problem could be expected to worsen.

Technology offers options. Home learning – accomplished via television and computer – represents one potential alternative to high transport and energy costs. Electronic links to data banks, libraries and other resources offer expanded educational opportunities at reasonable cost. For these and other cost-saving applications of technology, a model already exists. Pushed ahead of other states by climate and geography, Alaska has used a variety of such techniques for some time.

To take advantage of such options, policy makers will need to:

- *Examine and perhaps alter existing goals, policies, and requirements for: attendance, the length of the class day and school year, and home learning*
- *Explore, increasingly, cooperative activities among LEAs, SEAs, business/industry, and others to expand learning opportunities through technology – including teacher training opportunities.*

EQUITY

Already one hears legitimate voices of concern related to the new technology – concern that the "unlimited information" of the new technological era will not be accessible to all. Because of the cost of many of the new technologies, many fear that the gulf will widen between "haves" and "have nots" – between those who can afford the high-tech equipment which provides access to information and job skills and those who cannot.

This issue is a particularly important one for the public schools which have long played a key role in equalizing opportunities in the United States. If the new technological era is not to be one sharply divided between persons of great wealth, power and information and those of poverty and ignorance, then educators must consider:

- *How to insure that all students have access to the basic technological skills needed to function in the new age.*
- *How to ensure that funds, equipment, and access to information are distributed equitably among wealthy and poor communities and among students and staff within districts.*
- *How to use new technological advances to provide special opportunities for youngsters whose opportunities for learning and work have traditionally been limited by poverty.*

CONCLUSIONS

Like all society, public education is being swept into a new era of human experience by revolutionary changes in technology. No aspects of life will be unaffected: the way we work, live, play, study, worship, and even the way we think will be transformed. No one, and nothing, is exempt.

In the turmoil of that change there are also tremendous opportunities for human and economic growth. While educators have no choice about whether to enter the technological revolution, they have infinite numbers of choices about how to experience the change and how to shape it.

In choosing among options, educators will need to — as they do already — give high priority to two questions of critical concern:

- *What are the human, financial, and political resources required to bring America's public schools into the next century? Who is to provide them?*

- *How will the industrial age educational process be transformed to meet the demands of the technological age? By whom?*

Those questions — and many, many others — *will* be answered. They may be answered through the thoughtful, positive, *direct* action of educational policy leaders and their constituents or by other sectors and institutions of society, if educators do not choose to act.