Incidental Paper

Shaping the Nature of Future Literacy: A Synopsis

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Program on Information Resources Policy

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Executive Summary

This paper is concerned with information, technology, education, and literacy and with the dynamics interrelating these topics—dynamics leading to rapid changes with potentially major influence on educational practices and other important social functions. The first step—and the prerequisite for any further action—is to develop a thorough understanding of what is going on, and why. To that end, the paper briefly reviews and clarifies how these dynamics operate and examines their consequences, emphasizing those related to changes in the nature of literacy and in the educational requirements for individuals and nations to survive in the emerging information environment.

Related Publications

The thinking presented in *Shaping the Nature of Future Literacy: A Synopsis* is part of the author's continuing and developing study of issues in the area of computers and literacy. The following are the author's earlier works on this subject published by the Program:

Electronic–Print Competition: Determinants of the Potential for Major Change. Originally published in 1989, this was later included as a chapter in *Mastering the Changing Information World*, edited by Martin L. Ernst (Norwood, N.J.: Ablex Pub. Corp., 1993).

The Personal Computer: Growth Patterns, Limits, and New Frontiers (Cambridge, Mass.: Program on Information Resources Policy, P-91-6, October 1991).

Users and Personal Computers: Languages and Literacy, Costs and Benefits (Cambridge, Mass.: Program on Information Resources Policy, P-93-1, January 1993).

Computers and Literacy: Redefining Each Other (Cambridge, Mass.: Program on Information Resources Policy, P-94-5, August 1994).

Thinker, Zapper, Couch Potato: Shaping the Nature of Future Literacy (Cambridge, Mass.: Program on Information Resources Policy, October 1995).

Contents

A Note on Vocabulary

In times of rapid technological change, words can lose their traditional meanings as fast as physical equipment becomes obsolete. As with tangible items, the need for new descriptive words can arise suddenly and be met in an acceptable way only slowly. Two central themes of this paper reveal this problem of vocabulary, which has been handled in the following ways:

1. No suitable word is available to refer to the total mix of capabilities that digital electro-optics can provide, either in a single piece of equipment or in plug-compatible form, for creating, manipulating, storing, accessing, moving, and presenting information.

   • For variety, several words or phrases are used to describe that set of capabilities, such as "computers," "personal computers" ("PCs"), and "computers and associated equipment."

   • The usage is arbitrary. These particular words were chosen, because a well-configured personal computer of the mid-1990s comes closer to embodying the desired concept than any other type of widely available personal equipment. But how many of the functions mentioned in (1) will be incorporated into specific future systems, such as in the terminals of different networks, will probably remain uncertain for some time.

2. The first definition of "literacy" in most dictionaries refers only to the ability to read and write. Common usage has expanded "literacy" to mean understanding a variety of specialized subjects, such as "computer literacy," "science literacy," "gospel literacy," etc. The change is larger than first appears: reading and writing are concerned with the processes of preparing and absorbing information, while newer uses of "literacy" emphasize knowledge of the substance (what many people think of as content) of a subject written or read about.

   • As used here, the meaning of "literacy" is closer to the dictionary meaning, which emphasizes process, but it is also broadened to include ability to use all the tools widely available (at a particular time and place) for expressing, processing, and using information, rather than only reading and writing.

   • This is another example of the need for a word, and literacy, in its traditional meaning but broadened to include all relevant tools, comes closer than any reasonable alternatives to meeting that need.

One

Introduction: Problems and Purposes

Tremendous changes derived from interrelated technological, economic, and social forces are affecting all aspects of life and all classes of society. The products of these changes provide many benefits, but to individuals, nations, and even whole cultures they also present some severe problems difficult to cope with from a base of traditional attitudes and institutions.

At the heart of these problems is a revolution in the volume, importance, and type of uses of information materials resulting from the development of new tools that employ digital electro-optic technologies to create, process, move, store, access, and present information. These tools have changed the economics that apply to information, which consequently has grown into a larger, more important input factor (relative to other major input factors concerned with energy and physical materials) in practically all products and services used by a nation. As this revolution continues, all nations will become "information societies."

Changes arising in the economic and social environments have made it increasingly obvious that, in the future, for most individuals (and their nations) healthy survival and success will depend on familiarity with, access to, and skills in using the new information tools. In essence, a new form of literacy is evolving, one that builds on and extends traditional literacy in dramatic ways. So far, uses of the new tools have been limited in scope, but this will change. These tools will soon be applied to all significant human activities and, almost certainly, will eventually have large and critical roles in the general processes of education. The path to this future may be long and filled with perils from overhasty action or unnecessary delay.

This paper attempts the following:

- To review and clarify the dynamics of the changes underway;
- To examine their consequences, emphasizing those that will affect the nature of future literacy and related learning processes; and
- To illustrate both the limitations and opportunities for taking steps to survive effectively in the emerging information environment.

Two

A New Environment Arises

2.1 Advances in Digital Electro-Optical Technologies

The fast-paced changes in information processing were made possible by a series of advances in digital electro-optics the widespread effects of which were first felt about 1955. Now, in the mid-1990s, with no clear end in sight, there are good reasons to expect that change, turmoil, and uncertainty will continue for at least another two decades, and probably longer.

2.2 Support for the Advances: New Hardware and Software

For personal computers, which are of special importance to the nature of the future information environment, support for continuing rapid change comes from both hardware and software, somewhat inseparably.

On the hardware side, another two decades of dramatic improvement in performance and cost can be anticipated, based on technologies already identified. Further improvements appear likely, based on a variety of possible alternative system architectures and on the use of new device technologies, such as optical processing and storage.

On the software side, strong advances seem likely in the product sectors of control and communications programs, and even more in applications programs for both serious (task-related) and recreational purposes. To continue the pattern of rapid growth, however, more "surprises"—new and very different types of applications—will be needed. To some extent, these new applications can result from the improvements in hardware already noted; those advances can make it practical to employ techniques and computational operations impossible with the limited capabilities of earlier equipment. Among the application areas that should benefit are some that have received attention for many years, although with only limited success (such as those devoted to or dependent on computer speech recognition). Other areas have appeared so difficult and impractical to work in that, regardless of their longer term promise of marketable products, specific applications have not yet been well identified and defined. In these areas the potential exists for some radically new recreational and serious-purpose types of software.

The identification of new types of applications will be encouraged also by the increase in the numbers of skilled and experienced computer users, who will have been working with such equipment since early youth. These users will provide a larger and better base than was previously available for originating fresh ideas concerning market needs and new ways to

employ advanced computer equipment. One plausible outcome might be a considerable increase in the range of uses for computers, many of them quite simple on their own but with an overall effect of increasing the intimacy between users and computers.

2.3 Fast-Paced Change—But Directions Highly Uncertain!

Although there are good reasons to anticipate that the trend of rapid advances in digital electro-optics capabilities and applications will continue, many unexpected changes will occur. Some changes will lead to major adjustments in the general direction of progress, affecting both the types of equipment produced and the uses to which they will be put.

Volatility in the direction of change is not new; it can perhaps be better and more simply described as a continuation of the past pattern. In their only fifty-year lifetime, digital computers already have a long history of major assumptions unrealized and of unanticipated important opportunities arising. Dramatic transitions have been common: from an original total reliance on large mainframes, and later on a mix of mainframes with minicomputer equipment, to market dominance by personal computers; more recently, from stand-alone desktop devices to a mix of highly portable laptop or notebook computers, and even smaller personal organizers; and from independent PC stations to simple on-line PC operations and to complex, server-based, worldwide networking. Each move has found many unprepared for the changes. And similar conditions apply on the software side: the limitations of much-hyped disciplines and practices, such as Artificial Intelligence (AI), "Total Information Systems," and "Reengineering," among many others, illustrates the tendency for fads to arise, grow rapidly, and then collapse, to disappear or survive only at a lower level of use.

The future environment will almost certainly hold similar great uncertainties about likely markets for and offerings of information-related products and services, uncertainties that can pose difficulties for both industry suppliers and user organizations. Of particular importance to users will be the difficulties they face in formal planning activities; uncertainties will limit both the kinds of planning that can be trusted and the effectiveness of planning all longer term efforts. Similarly, individuals will be affected as they try to determine the type of education and skills that will best equip them to achieve success in life.

2.4 An Emerging Global Economy

The "global economy" that has been evolving was in part made practical by products of the new information environment. Economic pressures from increasing global interactions have created continuing, intense, worldwide economic competition, the impact of which, in combination with improvements in productivity partly flowing from better use of more extensive information resources has often been severe. A particularly painful example that

arose during the early and mid-1990s was the widespread practice, occurring in most industrialized nations, of downsizing respected, well-established organizations and of "leaning-out" the ranks of middle management, even when these steps violated traditional national cultural norms. Another almost universal feature of the new, highly competitive situation is the recognition that effective skills in information acquisition and processing are critical to organizational success.

This global pattern of competition seems likely to continue in the foreseeable future. Trends that have led to the current world economic structure are probably more vulnerable to change than those that produced the dynamism of the information environment, but the importance of a strong information capability is unlikely to diminish. Any major change, such as the rise of a more autarkic economic environment, would have an enormous range of impacts, but even if the relative values of specific types of information were altered, the net effect may well be an increase in the overall importance of information competence!

Three

Impacts, Benefits, and Burdens

3.1 Positives and Negatives of the New Information Technologies

Technological advances have contributed to both great benefits and growing problems.

On the ***positive*** side is explosive growth in the use of traditional and new forms of communications. Major gains in efficiency have been achieved in work, social, and personal activities. New types of products and services have flooded the market and, directly or indirectly, affected almost every human activity, whether business, government, professional practice, or recreational pastime, whether group endeavors or highly personal functions. Time and again, the new technologies have transformed whole industries, exerting enormous leverage by making possible huge gains in the capacity, speed and scope of information flows in support of such activities as transportation, communications, production planning and control, and financial transaction operations. The importance of more and better means of acquiring and applying information as an ingredient critical to the operations of our society is now built into social attitudes in most developed nations.

On the ***negative*** side, these same technologies have contributed to an environment in which people must face major losses in opportunities for secure and continued employment and organizations must face equivalent uncertainties concerning the erosion of their product lines, social functions, and general status in the life of the community. Another area of loss is in the value of many learned skills previously assumed to be of continuing importance to people and organizations. Even in sectors with strong economic growth, all types of workers (and their organizations) have been burdened with the need to learn, maintain, and extend a variety of new skills. Individuals too have begun to shoulder difficult new responsibilities to manage many aspects of their work and home information environments, and often these operations will require special new skills.

In effect, traditional patterns of employment and of important personal and home activities are undergoing major change. Among the results is a corresponding change in what it means to be a literate person and in the kinds of education and competencies becoming required for success in life.

3.2 What Makes Personal Computers Different—And Very Important!

Out of the turmoil they have helped produce, personal computers (and their associated equipment) have emerged as key tools for creating, editing, moving, storing, and using information. Anticipated advances in digital electro-optics will further strengthen the already dominant position of computers in many important information-intensive activities in the economy and in personal and social life.

The dominance of computers, which derives largely from a flexibility unlike that of any tool humans have previously employed, is exhibited in two ways:

1. Computers are, in effect, what might be called general-purpose Tool Holders and Interface Devices. Under user control, they can be converted with application programs into an essentially unlimited number of specialized information tools. It is as if a carpenter had a device consisting of a handle and some buttons, and as buttons were pressed, the device become a saw or hammer or drill or staple gun or sandpaper or glue, and so on. Such flexibility has already been exploited to make computers operate like "partners" in important situations. The availability of such highly personalized capabilities can be expected to increase over time.

2. Among the specialized functions computers can provide is easy transformation of physical carriers of information, between the durable forms necessary for storage of the information over time (such as ink on paper or magnetic patterns on discs) and transient ones (such as electro-magnetic waves or electric pulses) needed to move information rapidly or to modify or process it efficiently. By itself, this transformative power is an enormous source of value and a major contributor to the current status of computers.

The sources of value that have supported wide use of computers are strong, and their importance will grow as global digital-electronic infrastructures improve, enhancing practical opportunities to employ computer systems.

3.3 New Burdens: What Users Must be Able to Do

Use of the new capabilities, as suggested in section **3.1**, comes at a price: those who would enjoy the benefits (plus many "innocent bystanders") must deal with many problems associated with using computers. Some problems are new, others are radically enlarged versions of preexisting difficulties. Although the new user burdens are visible most directly in the work environment, they can also have a strong impact on important family and personal matters. A detailed examination of this subject would include the following areas of concern:

1. **Management of Information Flows.** Users must accept, locate, and acquire and handle more information (including "junk" and "near-duplicate" information) than ever before and when doing so must be able to employ new and more sophisticated processing, analytical, and presentation techniques.

2. **Management of Information Quality.** For users, this can involve making increasingly complex judgements about the balance in information timeliness, validity, presentation features, detail level, and costs to be sought when acquiring information materials for their own use and when producing information for use by others.

3. **Participation and Groupwork Skills.** These must be developed in order to work well on work teams and with social groups that may be widely dispersed and whose composition will often transcend national, linguistic, and cultural borders.

4. **Management of the User's Personal Work and Home Information Environments.** The skills required will range from those employed in minor personalization of resources and applications (in a well-supported organization) to complete responsibility for all aspects of information use (when no support is available and in most home situations).

5. **Acquisition of the Knowledge and Skills Needed to Understand and Be Competent in:** (*a*) Operating control programs employed on the computer(s) being used and (*b*) Computer application programs important to the user's work, personal needs, or other interests.

6. **Acquisition of Competence in the Underlying (Normally Noncomputer) Subject Matter Associated with the Various Applications.** In many circumstances, for example, when determining (*a*) how to use, correctly and appropriately, the different techniques available in a statistical analysis package, (*b*) how to search efficiently in a given type of database, or (*c*) how to create effective business graphics using a graphics application, extensive substantive knowledge of a subject may be needed in order to employ a computer application effectively, appropriately, and reliably. These examples offer a very small sample of a rapidly growing category of new user knowledge requirements. More radical and complex computer applications must be anticipated, which will compound the labor required to develop adequate understanding of relevant underlying substance.

3.4 The Need to Know More About "Many More Things"

The need for substantive knowledge concerning the subjects of applications may well turn out to be a "sleeper" because of potential growth in quantity and complexity. For a variety of reasons, the total amount of underlying substantive knowledge required of individuals in the future is extremely uncertain and could become very large indeed. In general, while people may not need to become smarter or wiser, they will need to know much more about many more things!

New Types of Equipment and Services. Part of the new substantive knowledge will concern new types of equipment and services (which will usually incorporate some form of computer control) for managing workplace, household, and entertainment operations. Although producers will try to keep consumer requirements simple—which means that most learning tasks will be uncomplicated—there will still be many requirements and frequent changes in control practices. For example, control instructions for videocassette recorders

(VCRs) of the early 1990s, baffling to many adults but not to their children, may prove to have been the starting point for what's coming on a large scale!

New Uses Require New Understanding. A larger and more serious component of the growing knowledge requirements will occur in the work environment, where computer capabilities are steadily being put to new uses that bring with them a need for associated substantive understanding. One simple example already mentioned (section **3.3**, item 6) illustrates how the requirements arise. The development of computer business graphics programs has resulted in a "deprofessionalization" of the creation of most such graphics. Organizations have come to expect that most or all their staff can design and produce the bulk of the graphics needed for presentations, reports, sales calls, and the like; professional artists are used only for the most important and most public situations. Thus, graphic skills can now be important to the careers of workers who previously regarded them as outside their areas of concern and necessary competence. On this pattern, requirements for new types of knowledge and skills are growing rapidly, both in numbers and in levels of complexity.

Changes in Social Practices. Other requirements may derive from changes in social practices, which in the early 1990s, began to move certain kinds of responsibilities from institutions onto individuals. For example:

- **Fairly complex financial planning.** As companies replace traditional pension plans with IRAs, 401-k's, and other similar arrangements, individual participants are being given more responsibility for managing the current investment of their retirement funds.

- **Personal health management.** Personal access to and evaluation of information from computer medical data sources can help individuals better understand their medical problems and put them in a better position to get the best care available to them from a given Health Care Provider.

- **Home shopping.** Consumers can make effective use of computers for home shopping activities, ranging from transportation and tourism to staples and specialty hard goods. Computer-based sources of information on how to shop effectively can become quite valuable for many situations.

Parallels of the new requirements existed in earlier periods, such as the growth in expectations that people would be able to understand and cope with a variety of written instruments (schedules, bills, money orders, rules and regulations, etc.), which arose in the nineteenth century as universal education first became widely available. Although the specific requirements may now seem simple, those first affected by them probably did not see them that way!

If the view that rapid improvements in the capabilities of digital electro-optics equipment will continue for several decades is accepted, then its corollary that computer applications and

their underlying use-related substances are constantly changing and growing in complexity also must be accepted. If so, then active learning, particularly with regard to applications-related substance, must become a continuing activity for people throughout their lives. The implications of this view for the educational system and the role of computers are enormous.

3.5 Computers to the Rescue?

How will people cope with the pressure of a pattern of lifetime learning, which seems to be emerging? What supports will people require? In particular, can the special capabilities of computers help solve, or at least mitigate, some of the many problems they have created? The answer appears to be "Yes," although many uncertainties remain about the extent and effectiveness of what can be done (see section **3.3**).

Computer application programs already incorporate features that provide considerable substantive assistance to users. Spell Checkers, Thesauruses, and Grammar Checkers in wordprocessing software, and Semantic Networks to support database search systems, are examples of this. Extensions of these types of aids should be a natural consequence of competition in the software market.

For many of the problem areas described in section **3.3**, support programs are already available, albeit often in primitive form. Search agents can seek out desired types of information from specified collections of databases, on either a continuing or a one-time basis. In a different configuration, such agents can serve as "sentries," employing user-selected specifications to limit or prioritize incoming (computer-readable) information. Generally, diagnostic and On-Line "Help" programs still are weak, and for those with limited computer skills they are often hard to use; but they are being improved and are evolving in the direction of gaining the capacity to serve as both "advisors" and "teachers" in specialized areas. These types of applications can be expected to continue to advance and expand in coverage and capability.

Interactive CD-ROM education support systems have grown very quickly in the marketplace, even though still in a state of "intellectual infancy" in terms of teaching capabilities. With increased producer experience in what does and does not work effectively and with new and growing markets for serious-purpose products, these systems should improve in capabilities. They may prove a particularly important tool for advances in teaching, given the potential growth in requirements for substantive knowledge acquisition (see section **3.4**).

Overall, although the growth of computer support and teaching capabilities may not be quick enough or extensive enough to balance fully the loads now placed on users, those loads

may be considerably lightened once computer-based support capabilities begin to be used more widely and more attention is paid to developing a greater variety of them.

3.6 Balancing Acts

Given the emphasis in this paper on the "dominance" of computers in information-related activities and on the growing "dependence" of individual and national success on possessing adequate competence in using them, it is important to note that this emphasis has its limits. No foreseeable advances in the capabilities of computers seem likely to displace all the information tools of the past. Their simplicity, effectiveness, and the low individual costs of many of them provide advantages in many day-to-day situations difficult for electronic devices to overcome. The ways that paper and pencils or pens are used in the home offers a good example of the case for continued use of these tools, even in an era of "fully electronic" houses (if or when that era arrives). Market forces will determine the balance between using simple, limited-purpose information tools—ranging from pencils and paper to various kinds of "relatively dumb terminals"—and more complex but highly flexible devices like advanced personal computers. The current trend is toward continued growth in the scope of computer uses and a parallel increase in their dominance of information-related activities, but not toward total exclusion of older tools.

Another important balance that will limit the market for flexible, general-purpose, computer-based tools is that between growth in the size, scope, and complexity of useful applications and growth and improvement in the means available (both visible and invisible to users) to simplify their use. No forecast of what this balance will be in the future can be accurate, but market forces are not likely to support either ignoring complexity or trying to simplify all aspects of an application. Again, the most sensible view seems to be that users will almost certainly have more complexity hidden from them, as well as better aids for dealing with the residual complexity; but, as long as rapid advances in hardware and software capabilities continue, users will also face new problems that will require new knowledge and skills.

As a result, until stability is reached, significant competence in the use of PCs (and their successors) and considerable knowledge about the subjects of various applications deemed useful by individuals or their organizations will be prerequisites for successful careers and effective management of more and more functions of personal life. At the national level, a labor force appropriately skilled in the use of PCs and their successors will be a key ingredient of economic strength and the national defense.

3.7 The Growing Role of Languages

Effective use of computers requires the ability to enter into the computer instructions and data or information that depend on two types of knowledge:

1. **Subject knowledge**, which assures that the user's purpose and plans are appropriate, valid, and realistic, and

2. **Computer instruction knowledge**, which assures that the computer will take the specific steps (within its limits) to produce the desired output.

Subject knowledge is normally acquired and transmitted through the common local (oral and written) vernacular, or person-person language, sometimes supplemented by graphics, images (still and moving), and various other special effects—video, audio, and what have you. Computer instructions involve person-device communications, employing special computer "languages." There are now many of these languages but no formal way to define them or get a good count of their number. Each major control, communications, and application language can involve a "vocabulary" equivalent to a very simplified version of a normal human language. Finally, the operations of computers critically depend on device-device communications, which are invisible to (most) users and thus easy to ignore. The importance of the special "languages" becomes clear, however, when, as is common, they are referred to as "standards" and "protocols."

These languages all share certain basic characteristics: (*a*) they employ accepted symbols (vocabularies) to represent events, states, actions, etc.; (*b*) they present the symbols in accepted orderings or structures (grammars and syntax); and (*c*) they use specific physical manifestations for providing strings of symbols that recipients (human or machine) can recognize (such as print on paper or spoken sounds to communicate with people, electric signals to communicate with and among devices, etc.). Beyond this commonality lie enormous differences in these languages, the most dramatic of which may well be the contrast between the ambiguity built into person-person languages and the rigidity of exact meaning required for one device to talk to another. Also important, computer devices are gaining in the ability to accept and respond in hybrid languages—mixes of alphanumeric, icons, audio, color coding, and still or dynamic graphics. Although individual pieces of these hybrids have been available for some time, packaging them in combinations, which is now increasingly easy, amounts to a new language "event."

As noted particularly in section **3.3**, a practical concern is the user's need to learn one or more of the special new languages required for all but the simplest use of a computer. Sometimes the associated subject background will also be required. As suggested in section **3.4**, as long as the pace of useful change is rapid, learning computer languages and associated subjects should be regarded as a continuing need in life for the foreseeable future. Given this

view, lifelong learning will be seen not as a take-it-or-leave-it matter but as a matter of dire and daily necessity.

Four

Toward a New Literacy

4.1 Literacy and Computer Competence

The connection between literacy and computer competence is direct, because literacy, in the broadest sense, combines:

- **Knowledge** of the nature of languages, that is, an understanding of their functions, and capabilities, and of problems (and limitations) associated with their use, and

- **Skills** in employing the more effective tools available for expressing languages within a given society and at a given time.

Computers have not only achieved dominance among tools used to process information (i.e., to "express language") in many work and social situations, but they also possess excellent potential for becoming even more "competent" in the future. Deep familiarity with them, and an ability to employ them effectively in work and social environments, must be regarded as a basic component of what it will mean to be literate in the future. This will be true even for skill levels now associated with only "basic" literacy.

In the future, lack of computer skills will carry a high price for individuals. Literacy-related abilities (for example, rhetoric, reading, and writing) have always been important and beneficial to those who possess them, providing improved ability to communicate effectively with others (especially one's peers), important elements of social belonging, and greater perceived status. More important, the elements of literacy are highly valued by most societies, because they offer the principal means for investigating and acquiring useful kinds of stored knowledge and for enjoying many means of entertainment. This feature leads to a "Learn to read, then read to learn" concept, which in some quarters has been used as a guiding principle for providing general education.

Faith in literacy as a key to learning will probably be strengthened by the increasing abilities of computers to perform teaching functions. Indeed, computer-based learning systems may even become a necessity if people are to keep up with substantive knowledge requirements for employing applications programs. This requirement may extend to what now are familiar skills, such as those needed to access traditional textual works like encyclopedias. In the future, significant additional skills may be needed to take full advantage of the special capabilities that can be built into CD-ROM incarnations of these types of publications.

4.2 Resources for Learning

Societies offer many and varied ways for their populations to learn. Environments range from the informal, largely unstructured learning children do at home to the formal, tightly organized study characteristic of most public elementary and high schools (and even more of military schools). Education goals can be broad and general-purpose, as in public school curricula, or narrow and focussed, as in learning directed toward acquiring specific employment skills. Delivery formats can be based on "osmosis," as in learning done in the informal or home setting; on the traditional model of instructors guiding students; on the two-way flow of a combination of written, audio, and video materials, live or remotely entered, provided by Correspondence Schools and their successors. Personal computers have already had an impact on all these systems, and their influence will, almost certainly, continue to grow—both as teaching devices and as themselves subjects to be learned about.

Experience with the use of computers in the environments discussed here leads to the following general observations:

In most technologically advanced societies, the economic benefits of acquiring specific work-related skills are so great that, once the need for those skills has been recognized, the means are provided, rapidly and efficiently. Thus, because training activities to help experienced workers learn specific early computer applications (e.g., for wordprocessing, accounting, automated airlines reservation operations, etc.) were simultaneously in the interest of equipment vendors, business customers, employees, and teaching organizations, it took very little time to develop training programs for them. Almost simultaneously, courses in the same subject areas were introduced into curricula of secretarial schools and schools for other kinds of white collar workers. The training was "narrow," and, in part because of this limitation, most training graduates tended to leave their computer skills at the office when they went home.

Most material on the effectiveness of home learning is anecdotal, but the anecdotes are so widespread that its potential effectiveness is clear, especially for the young. In at least four respects, home learning matches the needs of the young learning to use computers:

- For the young, learning new languages is normally easy, and, as already noted, language is at the heart of computer use.

- The young learner usually has free access to a computer at convenient times and can learn at an individual pace by "playing" with it—a style of learning to which the computer is ideally suited.

- The student can both learn from companions and at the same time offer help to them, rather than having almost exclusively to go to adults for guidance.

• The purchase of a home computer, by itself, indicates a parental level of interest and support in the learning experience that is likely to be encouraging to the learner. Most of us know nine- or ten-year-old children who are quite at home with computers; and, even if they use them mostly for games, the "feel" and familiarity they gain while playing will have a large payoff later in life.

Any program intended to change the nature of literacy throughout a nation's population must involve that nation's public school system. No other learning institution is likely to have adequate or similar coverage or support for such a program. In public schools in the United States, by the mid-1990s computers were already widely used, but usually only for limited and specialized purposes. Although the ratio of computers per students has been rising rapidly, it is still low (in 1992–93, about 1:12), so the "personal" relationship of computer and student possible in the home has not been possible in most public schools. So far, the results of having computers in the schools appear, at best, mixed. In particular, as yet there is no widespread view of what constitutes a successful program, or what needs to be done to create one. Much information remains, as said, anecdotal, and most favorable accounts come from wealthier and more information-friendly sectors of the educational system. Little is known, for example, to help judge how computers would fare, or could be made to fare, in inner-city schools.

Other weaknesses of available experience suggest that, in general, computers have been put in the category of "special-purpose" or "laboratory" equipment, and little effort has gone into integrating their use into day-to-day class work or homework (and few resources have been available to help in this area). Many computer-system acquisitions have been "one-shot" deals, with no plans or means to re-equip as the computers (rapidly) become obsolete. In the mid-1990s, most school computers did not come with internal or external modems, a lack that made it impossible to participate in some of the activities most exciting to young computer users, such as connecting to the World Wide Web.

In contrast to public elementary and high schools, colleges and universities are usually well furnished with equipment and prepared to offer appropriate venues for student (and staff) learning. In some cases, computers are integrated into curricula, and their use in specific courses can be required. In these situations, students may be furnished with equipment or at least helped to purchase it. In other cases, computer training courses are electives, which students may choose or ignore.

Finally, another source for learning valuable in the past in the United States is the public library. Since the middle of the nineteenth century, this institution has been important in the democratization of access to and the use of print information. By the mid-1990s, libraries were making extensive use of computers, but had not yet found a suitable way to offer significant patron-use computer capabilities except in relation to traditional library operations

and for the use of selected reference materials. Whether, in the learning environment of the future, libraries or some other type of institution will play a role equivalent to the traditional library one, or whether that role will be found unnecessary or impossible to fill, is not yet known.

4.3 Imbalances in the Use of Resources

The resources made available for learning about computers and how to use them are responsive to many political and economic forces. The benefits of the these resources, like those of other new technologies being introduced into daily life, are distributed unevenly among potential participants. Part of this effect is probably transient; as the use of computers spreads, at least some of the main imbalances will shrink or even disappear. Until then, the impact of uneven levels of access to training in computer skills and to knowledge about computers can be socially significant, painful to some segments of the population, and very difficult to correct.

4.3.1 Some Important Factors

The main factors influencing early development of computer skills are well known. Direct and effective experience is largely a matter of family economic status. Good early encounters occur mainly in neighborhoods served by good public elementary and high schools, and the effect of such encounters is amplified in families that can afford to purchase personal computers for family use.

Choosing to live in a good school district often reflects a strong commitment to schools and to active participation in how they are run. This commitment on the part of parents adds an incentive for their children to become "learners," both at home and in school.

The better sources of information usually charge for access to their resources, and these costs tend to increase economic imbalances. At colleges and in job training courses, adequate opportunities for experience with computers will almost always be available, but the experience provided to students who do not have their own computer equipment can be limited, formal, and narrow—and thereby provide only a weak basis for extended learning and retraining in the future.

Although much lip-service has been paid to the notion of life-long learning, fulfillment of this growing requirement is left largely to the marketplace and to individual initiative. The means available are diverse enough to offer something for everyone:

- Formal training courses are operated by many different kinds of organizations, ranging from business organizations established to market training to mutual support furnished by

computer clubs, hobby groups, on-line study groups, and others. Many less formal sources charge only small fees (or none).

- Employer-supported training can be important for maintaining work skills during a period of change, although employers have little motivation to provide most personnel with learning experiences other than narrow, highly focussed training in new techniques or in special new areas of their organization's activities.

- An exception to the limits stated in the second bulleted item is the more educated members of an organization, particularly professional and technical staff, because updating their skills can be more broadly important to the operation of the organization. Much updating will be expected from staff members' continuing self-education, but this usually will be supplemented by organizational support for attendance at professional meetings, conferences, seminars, short courses, and the like.

Overall, learning opportunities abound in the United States, and many are affordable by a large fraction of the population. The responsibility for finding and using these opportunities, however, lies mostly with the individual, and although institutions can help, the individual must initiate and manage the action. The one population that remains an exception is the young, because, owing to the economics of access to computers, most of them are not in a position to initiate effective personal action to acquire experience and training.

4.4 Universality and "Ripeness"

In the United States in the mid-1990s, attitudes toward literacy incorporate several beliefs and notions. One is the strong and widely held belief in the value of traditional literacy, which helps support a willingness to provide universal education so that all members of the society can achieve at least basic literacy. This belief is combined with a growing recognition that computer-related education is important, that it is properly a part of or supplement to traditional literacy. But this sense is not yet strong enough to justify support for an analogous universality of basic computer-related competence.

The difference in attitudes toward universality is significant. One implication is that the computer is not yet truly built into people's lives, in an everyday sort of way, sufficiently to merit the support needed to make it into a universal tool. It is not yet "mature," or "ripe" enough, to justify the costs for taking such action.

If the views expressed in this paper about the future roles and importance of computers and associated equipment are sound, then in time that ripeness will be achieved. For it to occur, important changes are required. A larger group of everyday uses for computers, will be needed, including some of value to essentially all members of society. The role of computers in public education will have been expanded, so that experience will have been

acquired that provides a basis for improved understanding of the ways computers can be effective in general education and of feasible, appropriate goals for their use in different grade levels and curricular elements. The goal is to fit uses of computer equipment into a variety of classroom activities and curricula for all the grades. Computer use must approach a level that requires students to have access to suitable PC equipment both in school and at home.

On the economic side, for computers to meet the political realities of any large-scale school program—especially one that recognizes explicitly the short life span of equipment before obsolescence—the historical trend toward lower prices for improved effectiveness must continue. The transition in computer education will be helped by recognizing the potential for new jobs to be created and new profits generated from expanding markets for products and services to involve segments of the population not currently making significant use of computers. Whether to offer universal services in a society depends on many factors; in the United States, the most effective motivations appear to be a combination of human benefits, economic benefits, and considerations of equity.

The changes described here are evolutionary and represent a continuation of current trends. Much small-scale experimentation may be required, and formal ways to consolidate information on the experience gained will be desirable. No massive research or large installation program is likely to be worth the effort at this time. The weaknesses of such programs can be illustrated by noting that had one been started in the early 1990s, it would almost certainly have failed to mention, much less incorporate use of, the Internet! The uncertainties of the information revolution are too great for traditional longer term planning in areas touched by literacy and education. In the current environment, it is probably best to have a bold vision of the future for guidance but detailed planning should be short-term and incremental, emphasizing rapid implementation, steady building, and planned, continuing improvement.

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