The Technology Coordinator

International Society for Technology in Education
ISTE

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Preface

Educational leaders throughout the world are calling for school reform and school restructuring. More and more people are coming to realize that their current educational systems are not adequate to the challenge of the Information Age. Many of our school graduates, as well as an even larger percentage of our school dropouts, are not adequately prepared to deal with the changing challenges of a world that is placing ever increasing emphasis on INFORMATION—information as a product and information as an aid to solving problems. Schools need to help prepare students to make effective use of computers and computer-based hypermedia as an aid to learning and problem solving.

Many businesses have met the challenge of the Information Age by installing numerous information processing facilities and training workers in their use. Although at a much slower pace, our school systems are also doing the same thing. The "workers" in our schools are the students and the staff. Eventually all will have very good access to a wide range of information technologies. Eventually every school will have a support structure designed to ensure that the hardware and software facilities are in good repair. They will have staff to help both students and teachers learn to make effective use of the facilities.

Throughout this book we will generally use the word "computer" to mean both computers and a computer-based multimedia environment that includes a wide range of information acquisition, storage, processing, and delivery devices. It is becoming common to use the word "hypermedia" to refer to this teaching, learning, communicating, problem-solving environment.

This book is written for educators who want to play a leadership role in the instructional use of computers and other information technology facilities in precollege education. The main orientation of this book is toward schools in the United States and Canada. However, many of the ideas are applicable in other countries. This is because the Information Age is a worldwide phenomenon.

It is assumed that the reader has some familiarity with computers and computer-related equipment. For example, it is quite likely that the typical reader uses a word processor and has used a variety of pieces of educational software. Many readers will have had experience with use of a variety of media equipment such as CD-ROM, laser disc, camcorder, and audio recorders.

The first edition of this book was published in February 1985 with the title, *The Computer Coordinator.* Since that time, the number of computers in schools has grown immensely; the quality and capability of computer hardware and software has grown substantially; and the complexity of the computer coordinator job at the school and at the school district has continued to increase.

Moreover, the nature of the "computer coordinator" job has changed. The past seven years have seen a massive switch in computer use in schools from computer programming to computer applications (computer-as-tool) and to computer-assisted learning (CAL). The idea of a hypermedia classroom has emerged. (A hypermedia classroom provides students and teachers access to a wide range of electronic and non-electronic information technology facilities. The facilities may be used to create interactive, non-linear materials that are called hypermedia documents.) Computer networks have become common. Telecommunications—electronic mail, electronic bulletin boards, electronic conferencing, and use of online databases—has grown very rapidly.

The emphasis has switched from a focus on the computer itself to a focus on learning environments that are facilitated by computers. A hypermedia classroom may make use of a very wide range of electronic media equipment, such as VCR, camcorder, videodisc, CD-ROM, audio digitizer, scanner, laser printer, impact printer, PC-viewer, slide projector, and computer. Students in this classroom may have access to a telecommunications network that reaches throughout the building, the school district, and the world. This network provides access to people and to information. While a computer "glues" all of the components together, the computer is certainly not the central focus. The central focus is learning and communicating, and most often both the learning and the communicating are focused on a non-computer topic.

Because of this, the title "computer coordinator" has become outdated. In this book, we use the title "technology coordinator" (TC) to designate an educator at the school level or at the school district level who works to facilitate effective use of a wide range of computer-related information technologies in instruction.

The current version of the book addresses some of the changes of the past seven years. Interestingly, many of the basic ideas underlying the field of computers in education have not changed appreciably over this period of time. Thus, a substantial portion of the original content of *The Computer Coordinator* is contained in *The Technology Coordinator*.

The book is divided into three main sections. The first part, extending through Chapter 10, is a short treatise on the general topic of a TC. The second part contains interviews with a number of TCs. The third part contains a number of articles I wrote between 1983 and 1990. They provide historical perspective and highlight many of the major issues faced by a TC. Each of the three sections is relatively independent of the other two, so that the reader may wish to browse all three before settling down to reading the book from cover to cover.

David Moursund

August 1992

Chapter 1

Overview of Computers in Instruction

In 1837 Samuel Morse applied for a patent on an electrical, key-actuated telegraph system. It made use of a code he had developed about five years earlier. Public use of Morse's electrical telegraph system was inaugurated on 24 May 1844 with the message "What hath God wrought?" being sent between Baltimore and Washington. Clearly this was the beginning of a major change in our society—a change based on rapid and relatively reliable communication over long distances.

The telephone, invented in 1876, has certainly contributed to this change. It is a more "user friendly" device than a telegraph. It could be installed in people's homes and its use required little or no formal training. It is important to realize that the telephone has become so user friendly that young children learn to use it merely by imitating adults, even before they go to school. They do not receive instruction in "telephone literacy" in school.

We are already seeing the same thing happen with computers. Many children are literally growing up with computers. Their first exposure to computers comes from sitting on a parent's lap while the parent uses a computer at home. We now have innumerable examples of preschool children making use of computers alongside other childhood toys and learning aids. For such children a computer is merely part of the everyday environment. Such children learn to use computers in much the same way in which they learn to use a telephone or a VCR.

Any major change in a society is eventually reflected in its educational system. Computers and related electronic technologies have greatly changed our society and our world. They are now poised to promote a revolutionary change in our educational system. This change may be compared to changes wrought by books, and certainly it has some similar characteristics. Books allow the storage of information over time and the transmission of information over distances. Books allow easy access to information at a time and place convenient to the user. Books have changed the basic nature of education and of our world. *Books empower people who know how to read*. We have designed our educational system so that it enables a high percentage of young people to learn to read and write.

The telegraph, telephone, radio, television, tape recorder, video recorder, and other modern aids to communication also allow the storage of information over time and/or the rapid transmission of information over distances. The computer further increases the ability of electronic systems to store and transmit information. In recent years there has been a major effort to improve our ability to create, edit, store, and transmit still and motion pictures. Progress in this area lies at the heart of the rapidly increasing educational emphasis on hypermedia. In the same way that schools focus on helping all students learn to read and write text, it is now clear that the schools of the future will place major emphasis on helping all students to "read and write" hypermedia.

Computers add a new dimension to communication, since they can aid in the processing of information. Not only can a computer store information about solving complicated problems, it can store computer programs that can actually solve or help solve the problems. Some of the programs are quite simple; a beginning programmer might easily write such a program in a few minutes. Others are quite complex, requiring many person/years of programming effort.

Some make use of ideas from artificial intelligence. Increasingly, artificially intelligent "expert systems" are coming into use in business and research. An expert system is a computer program that attempts to capture some of the human expert knowledge needed to solve a certain type of problem. There are profound educational implications to such systems becoming increasingly powerful and increasingly available. Do we educate students to compete with computers, or to work with them?

One of the most important and fundamental ideas in the computer field is that of an effective procedure—a detailed step by step set of directions that can be carried out by a computer. The idea of an effective procedure will undoubtedly prove to be one of the most important contributions to human intellectual activity of all time. Procedural thinking is the type of thinking used to develop and to make use of effective procedures. Children raised and educated in a computer environment learn a great deal about procedural thinking even if they receive no explicit instruction in this area. However, explicit instruction in procedural thinking solidifies and extends knowledge and skills in this area.

Educators and researchers are a long way from fully understanding the capabilities and limitations of computers, or how computers should affect education. What are the long term effects of a child making extensive use of the current computer-assisted instructional materials? What are the limits to expert systems and to other research areas in the field of artificial intelligence? Will we eventually have intelligent computer-assisted learning systems that rival or surpass teachers? How does progress in the computer field affect the teaching and learning of problem solving? If a computer system can solve or help solve a particular category of problems, what should students learn about solving this category of problems?

Some Key Questions

As computers become cheaper and more readily available, educators must deal with five basic types of questions.

1. Improving education by empowering students and teachers: Technology empowers its users. In what ways is our overall educational system improved by providing students and teachers with good access to computers and other information technology facilities along with good education on how to make use of these facilities? There are many sub-questions under this main heading. For example, how can teachers provide useful feedback to students who are working in a hypermedia environment, and how can teachers adequately assess this type of student work?
2. Learning about technology: What should students learn about computers and other information technology, and in what context should they gain this knowledge? For example, should all students be required to take a "computer literacy" course, and should we assume that successful completion of such a course adequately prepares a student to deal with computer-related technology?
3. Learning to learn: How can computers and other information technology help students to learn? (Does learning to learn become a more viable and important component in the curriculum as technology-based aids to instruction such as computer-assisted learning and distance education become more readily available?)
4. Impact on curriculum content: How should computers and other information technology affect the content of the subjects students currently study in school?
5. Technology coordinators: What level of technology coordinator support is needed in a school and in a school district to help students and teachers learn to make effective use of hypermedia facilities for learning, for communicating, and as an aid to problem solving?

These are very difficult questions, and answers change over time. But parents, students, and educational leaders want answers now!

You will note that each of the above question asks about both computers and other information technology. Initially, computers were large, quite expensive, and required a great deal of expertise to use. However, over the years computers have become much cheaper, smaller, easier to use, and more versatile. Now it is common to build computer circuitry into microwave ovens, cars, TV tuners, VCRs, children's games, and a host of other equipment. Worldwide production of integrated circuits in 1990 was roughly equivalent to seven such circuits for every person on earth! By the year 2002 it may well be double this, and the number of components in an integrated circuit continues to grow rapidly. The increasing sophistication and cost effectiveness of such integrated circuits is helping to make laptop and palmtop computers commonplace.

In the late 1980s, many schools began to experiment with hypermedia. Students began to work with a combination of computer, VCR, videodisc, camcorder, CD-ROM, scanner, audio digitizer, and other electronic equipment. It became evident that such a hypermedia environment empowers students and teachers. It allows them to undertake tasks that they could not do in the non-computer classroom environment.

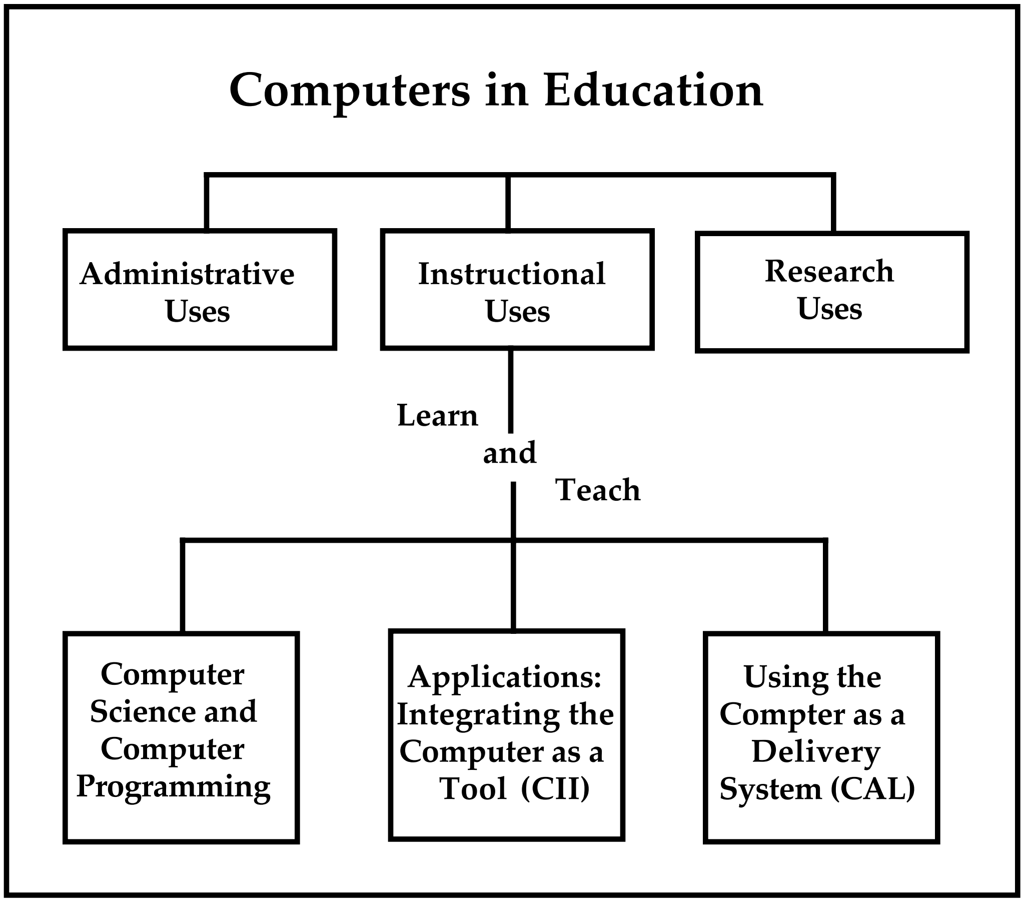
Of necessity, the role of the school or district computer education specialist expanded to dealing with all types of electronic technologies. The title computer coordinator began to become somewhat out of date, and the titles technology facilitator, technology coordinator, and instructional technology coordinator began to emerge. This book uses the term technology coordinator (TC) to designate a person at the school or district level who works as a leader in instructional uses of computers and other information technology.

TCs at the school building level and at the school district level are being expected to develop and implement answers to the five difficult questions listed above. They have been cast in the role of leaders; they are asked to play a significant part in a major school restructuring revolution that is sweeping our educational system.

This book is for people who are currently TCs, or who are thinking about obtaining one of these positions. It is also for school administrators who are exploring the possibility of creating TC positions and hiring TCs. The book analyzes TC responsibilities and suggests needed qualifications. It also examines the nature of many current TC positions; several interviews with TCs are included. In addition, this book explores a number of ideas about school restructuring. The emphasis is on restructuring for the Information Age.

Computers in Education

The overall field of computers in education may be divided into administrative, instructional, and research uses. Each may be further subdivided. The emphasis in this book is on instructional uses. Thus, the diagram given below shows subdivisions for that aspect of the field of computers in education.



The overall field of instructional use of computers may be divided into learning/teaching about computers, learning/teaching integrating computer-as-tool (computer-integrated instruction, or CII), and computer-assisted learning (CAL). Each component of this three-part model of instructional use of computers emphasizes that both students (learning) and teachers (teaching) are essential. The model differs slightly from and is a little more general than the "tutor, tool, tutee" model popularized by Robert Taylor (1980).

A TC holds a leadership position, interacting with classroom teachers, curriculum specialists, and school administrators. This leadership position involves dealing with all three major components of instructional use of computers. This chapter defines the three components while the next three chapters contain a more detailed examination of the components from a TC point of view.

Learn and Teach About Computers

In learning/teaching about computers, the field of computer science, along with related areas such as information science and data processing, is considered as a subject area. The computer field is clearly an important academic discipline. Many community colleges, colleges, and universities offer degree programs in this discipline. Thus, schools need to make a decision about what to teach from this subject area. Some schools express this decision as a goal that all students should become computer literate, and thus require a computer literacy course. Other schools specify a list of courses that are to be offered as electives, such as various programming languages, an advanced placement course, a robotics course, or an electronics course. Still other schools integrate instruction about computers into a number of curriculum strands.

It is important to realize that the computer-related disciplines are now well established even though they continue to grow and change rapidly. For example, the Association for Computing Machinery (ACM) is a large professional society that began in 1947. In 1968 the ACM Curriculum '68 specified details of a college undergraduate curriculum of study. Those recommendations were updated about a decade later in Curriculum '78. A still more recent version of this curriculum is scheduled to be released in 1992. Other college-level curriculum recommendations have been developed by the Computer Society of the Institute for Electrical and Electronic Engineers, and by the Data Processing Management Association. Both of these organizations are large professional societies of people interested in the computer field.

At the two-year college, four-year college, and university levels, computer science departments have existed for 15-25 years and more. There are hundreds of associate and bachelor degree programs. In North America there are about a hundred doctoral programs in computer science. There are hundreds of research journals as well as a great many popular periodicals carrying computer-related articles.

Because computer science is a large and well established discipline, it is natural to ask whether there should be a scope and sequence of computer science instruction at the precollege level. If such a question is raised in a school or school district, the TCs will be asked to help provide answers. This may require a substantial background in the field of computer and information science. This is discussed more in Chapter 4.

Applications: Learn and Teach Integrating Computer-as-Tool

In learning/teaching integrating computer-as-tool, the computer is considered as an application tool in the various academic disciplines. The emphasis is upon learning to use computer application packages and integrating them as everyday tools into a student's overall knowledge and skills. We shall call this computer-integrated instruction (CII). Standard examples of CII software include word processing, graphics, spreadsheets, and databases.

In recent years, three somewhat disjointed types of tool uses of computers and hypermedia have developed. There are tools that cut across many disciplines, such as a word processor or a camcorder. We call these generic tools. There are tools that are quite specific to a particular academic discipline, such as hardware and software to aid in musical composition and performance. We call these subject specific tools. Finally, there are tools that require some programming skills, but where the focus is on learning to learn and on learning non-programming areas. The Logo programming language is an example, as are the hypermedia environments facilitated by *HyperCard* and *LinkWay*; we call these learner centered tools. We will discuss CII more in Chapter 6.

A very simple example of computer-as-tool is provided by the hand-held calculator. Progress in incorporating calculators into the curriculum has occurred, but it has been slow. One difficulty is that the established curriculum, backed up by teacher knowledge, curriculum materials, and standardized testing, is quite resistant to change. Many potential tool uses of computers face similar resistance, and a TC must deal with this resistance.

Progress in developing more and better applications packages, as well as better human-machine interfaces, is causing CII to grow rapidly. Also, computer scientists working in the field of artificial intelligence are producing application packages that can solve a variety of difficult problems—problems that are generally considered to require a substantial amount of human knowledge and skill. Such application packages may eventually change the content of a variety of school subjects. The key issue is what students should learn to do mentally, what they should learn to do assisted by simple aids such as pencil and paper or book, and what they should learn to do assisted by more sophisticated aids such as calculators, computers, and computerized equipment. These are very hard questions. The slow acceptance of the hand-held calculator into the curriculum suggests that more sophisticated aids to problem solving will encounter substantial resistance.

One can also examine the computer as a tool to increase teacher productivity. The use of a computerized gradebook, a computerized data bank of exam questions, a computerized system to help prepare an IEP (individualized educational plan) for a student with disabilities, or even a word processor to write lesson plans and class handouts are all good examples. Generally speaking, the role of a TC here is to encourage such computer use by helping to provide appropriate hardware, software, and teacher training. Since such computer use may simplify the teacher's job, it is a good way to get teachers hooked on computers.

Computer-Assisted Learning (CAL)

Computer-assisted learning includes computer-assisted instruction and computer-managed instruction. Chapter 5 examines the role of a TC when the computer is considered as an instructional medium. A computer might be used in a supplementary mode, with students making a modest use of computers to reinforce instruction provided by other means. Research into computerized drill and practice suggests that this mode of supplementing instruction is quite effective in a variety of subjects.

In this book we will discuss distance education in the same chapter with CAL. A distance education environment may include one-way video and two-way audio, two-way video and audio, or a variety of other communication strategies. It may include CAL. For some students and/or in certain subject areas, distance education and/or CAL might be a primary mode of instruction. This type of use is increasing rapidly and seems highly likely to continue to increase in the future.

The computer can be used for instructional delivery at every grade level, in every subject area, and with all types of students. Evidence is mounting that CAL is especially useful in special education and in basic skills instruction. In addition, CAL and distance education can provide students access to courses that are not available in a teacher-delivered mode in their schools. Already we are seeing signs that the CAL and distance education packages being sold to schools will become cheap enough so that many parents will consider purchasing them for use with their children at home. This is adding a new dimension to our educational system.

Concluding Remarks

A computer is a tool that empowers its user. It is a mind tool, an aid to the human brain. The computer is proving to be a powerful change agent in our society. Moreover, the computer is an agent of relatively rapid change. This is a challenge to our educational system, since it was not designed to deal with rapid change.

For example, at one time it was common for teachers to receive their formal education and then receive lifetime certification. The underlying assumption was that there was no need for additional formal "inservice" education in order to keep up with one's field. Now, however, this is definitely not the case. Many academic fields are changing quite rapidly. The computer cuts across all academic disciplines, so every teacher faces the challenge of the rapid pace of change in the computer field. It takes a great deal of knowledge and skill to make effective use of computers in disciplines such as science, social studies, music, business, or industrial arts. A few teachers have been able to learn on the job. However, most teachers do not have the time and energy to adequately learn the computer field while coping with all of the demands of their teaching jobs.

The International Society for Technology in Education has an Accreditation Committee that is developing recommendations on needed levels of preparation for teachers who will be teaching about and making use of computers. A recent report from this committee (ISTE Accreditation Committee, 1992) summarizes some of the progress this committee has made. The approach is to get the recommendations approved by the National Council for Accreditation of Teacher Education (NCATE). NCATE has approved the ISTE recommendations for teacher education programs that prepare computer educators. These recommendations also help to define needed computer competencies of all teachers.

The need for release time for inservice education is evident. Moreover, the need for one-on-one inservice, individualized to a teacher's own specific needs, is also evident. This is aided by having adequate computer facilities in every classroom and adequate facilities for teachers to use both at home and at school. A major role of the TC is to design and help implement the staff development that facilitates appropriate use of computer-related technology in schools. Information on staff development for computers in schools can be found in Moursund (1990b).

Chapter 2

Goals of Education and of Computer Use in Instruction

First and foremost, a TC is an instructional leader working to improve the education that students receive. This requires a good knowledge of students and of the overall goals of education. This chapter provides a brief overview of the goals of education. Based on these goals, it gives an overview of a set of goals for computer use in instruction. Computers are an aid to problem solving in every academic discipline. In addition, computers make possible reasonably priced hypermedia as an aid to learning and as an aid to communication. These two aspects of computer-related technology are beginning to have a strong impact on education.

School Reform

The 1980s witnessed a steady parade of calls for school reform, and such demands have not lessened in the early 1990s. There have been dozens of major studies suggesting that American schools are not doing as well as people would like. Recommendations range from "back to basics" to placing much greater emphasis on problem solving and other higher-order thinking skills.

There has been considerable emphasis on cooperative learning and on interdisciplinary studies. Many of the reform movement reports call for helping all students to become computer literate or for computer technology to receive greater attention in our schools. A summary of some of the reform movement reports is given in Cetron (1985). The publication OTA (1988) is a very important contribution to the field of technology in education. An overview of many of the key ideas on the teaching of problem solving in schools is given in Moursund (1990a). A report from the International Society for Technology in Education (Braun, 1990) contains a number of recommendations for government leaders and educational policy makers. A sampling of other school reform references include Dede (1990), Dertouzos (1991), Goodlad (1990), Kinnaman (1990), Mecklenburger (1990), Pearlman (1990), Reich (1991), Salem and Minz (1991), and Schulz (1991).

Finally, it is worth noting that education has even become a major issue in politics. George Bush, who was elected as President of the United States in 1988, has indicated that he would like to be remembered as the "education" President. The Bush administration has convened a number of school reform meetings, including a meeting with all of the states' governors. The publication U.S. Department of Education (1991). summarizes some of the key ideas being supported by the Bush administration.

In the late 1980s, American businesses began to display increased concern about our schools. Many business leaders indicated they felt that our schools were not adequately preparing the work force needed in business and industry. The Business Roundtable (April, 1988) was formed, and it has channeled considerable private sector resources into education. The number of education/business alliances has grown, and it is clear that such cooperative efforts are contributing to school improvement.

Goals of Education

It seems clear that we are at the beginning of a major change in education. The Information Age is upon us, and a number of educational trends and megatrends are beginning to reshape our schools. Chapter 3 of this book includes a list of some of the major and continuing trends (megatrends) in the field of computers in education that are shaping our school system. It is generally agreed that through improved teacher education, school reform, and appropriate use of electronic technologies, we can greatly improve our school system (Braun, 1990).

A great deal is known about the process of educational change (Fullan, 1982; 1990). The research indicates that major change in education is a long, slow process that requires a great deal of effort on the part of people working to make the change. One major vehicle for school improvement and change is staff development. A summary of staff development practices that have proven effective in the field of computers in education is given in Moursund (1990b). Research on school change through staff development indicates that it takes three to five years of carefully organized staff development in a school to implement a significant change in the school curriculum.

The intent of educational reform, of course, is to improve education. A starting point for the study of school improvement is to examine the missions of education. The following discussion of educational missions comes from Moursund and Ricketts (1988). This is a very brief discussion of a very complex topic; it is intended to be suggestive rather than comprehensive.

First, it is important to realize that education is a very large institution. As such, it has three underlying goals or unifying themes:

1. **Life**: Our school system as an "Institution" has had a long existence and seeks to preserve itself. Our educational system will strongly resist changes that threaten its existence.
2. **Resource**: A school system is a repository of knowledge and a vehicle for the dissemination of this knowledge. It is knowledgeable educators, libraries, school facilities, and pedagogical traditions. A school is a valuable part of the community in which it resides.
3. **Service to Students**: The bedrock goal—the basic mission; schools exist to educate students, to help students to learn and to "grow."

The service mission can be broken into a number of parts. The following list is a composite drawn from a wide range of literature sources. These Mission Statements (MS) are stated in a positive manner, as missions being accomplished.

Conserving Missions

MS1 **Security**: All students are safe from emotional and physical harm. A school must be a safe, secure, "home away from home," designed to promote learning.

MS2 **Full Potential**: All students are knowingly working toward achieving and increasing their healthful physical, mental, and emotional potentials.

MS3 **Values**: All students respect the traditional values of the family, community, state, nation, and world in which they live.

MS4 **Environment**: All students value a healthy local and global environment, and they knowingly work to improve the quality of the environment.

Achieving Missions

MS5 **Basic Information Skills**: All students gain a working knowledge of speaking and listening, observing (which includes visual literacy), reading and writing, arithmetic, logic, and storing and retrieving information. The underlying orientation is to gain basic knowledge and skills useful in dealing with the full range of problem situations one encounters in life.

MS6 **General Education**: All students have appreciation for, knowledge about, and some understanding of:

- History and change.
- Nature in its diversity and interconnectedness.
- Religion, the professed relationships between humans and a deity.
- The artistic, cultural, intellectual, social, and technical accomplishments of humanity.

MS7 **Lifelong Learning:** All students learn how to learn; they have the inquiring attitude and self-confidence that allows them to pursue life's options.

MS8 **Problem Solving**: All students make use of decision-making and problem-solving skills, including the higher-order skills of analysis, synthesis, and evaluation. All students pose and solve problems, making routine use of their overall knowledge and skills.

MS9 **Productive Citizenship**: All students act as informed, productive, and responsible citizens, members of organizations to which they give allegiance, and to humanity as a whole.

MS10 **Social Skills**: All students interact publicly and privately with peers and adults in a socially acceptable and positive fashion.

MS11 **Technology:** All students have appropriate knowledge and skills for using our rapidly changing (Information Age) technology as well as relevant technologies developed in earlier ages.

Not every school district accepts all of these Mission Statements, and many school districts are not adequately achieving these missions. Moreover, it is not easy to accurately assess the nature and extent to which each child achieves the goals underlying these Mission Statements. However, in general, these Mission Statements provide a good starting point for addressing schools goals and possible changes in schools to better achieve the goals.

It is evident that each of the Mission Statements can be achieved at a variety of levels. In isolated communities, the "competition" that students encounter comes from within the community, and so local standards are appropriate. Increasingly, however, students are no longer preparing for adulthood in an isolated community. Rather, they are preparing for adulthood in a national or world community. Thus, we are gradually witnessing the development of a set of world standards. The development of such standards, and assessment across national boundaries, is a major challenge to world educational leaders. Information about recent international assessment in the field of computer technology is given in Pelgrum and Plomp (1991).

An educational system is complex, with many interwoven components. It is not easy to design a system that successfully accomplishes a list of Mission Statements such as that given above. Moreover, it is not easy to measure whether a school system is successfully accomplishing such a list of Mission Statements. It is not surprising that many of the school reform and school restructuring studies call for changes in methods of assessment.

The literature in this area is growing rapidly. Examples include Charles, Lester, & O'Daffer (1987), Frederiksen & Collins (1989), Nicherson (1989), Rogers (1990), and Stiggins (1991). There is increasing emphasis on assessment being more "authentic"—that is, more closely related to the types of tasks to which students will apply their knowledge when they become adults. If a student is learning to write and to solve problems in a computer-rich environment, then the student should be tested in the same environment. Portfolios and electronic portfolios (hypermedia portfolios) are beginning to come into our schools.

Computers in Education Goals (CEG)

The following list of goals for computers in education is drawn, with minor modifications, from Moursund and Ricketts (1988). It is based on a careful analysis of current literature and current practices within the field of instructional uses of computers at the precollege level. Such a list of goals can be used as a starting point for long-range planning for computers in schools.

CEG1 **Computer literacy (hypermedia literacy).** All students shall be functionally computer literate (hypermedia literate). Many educational leaders now consider this to be part of MS5: Basic Information Skills. The redundancy in using the two expressions "computer literacy" and "hypermedia literacy" is to emphasize the changing nature of computer literacy in the past decade. In this book, hypermedia literacy is an extension of computer literacy. Functional hypermedia literacy can be divided into two major parts:

A. A relatively broad-based, interdisciplinary, general knowledge of applications, capabilities, limitations, and societal implications of computers and other information technology to be achieved by the end of the eighth grade. This has four components:

1. Talking and reading knowledge of computers and other information technology, and their effects on our society. More specifically, every discipline that students study should teach them something about how electronic aids to information processing are affecting that specific discipline.
2. Knowledge of the concept of effective procedure, representation of procedures, roles of procedures in problem solving, and a broad range of examples of the types of procedures that computers can execute.
3. Basic skills in use of word processing, database, computer graphics, spreadsheet, telecommunications, and other general purpose, multi-disciplinary application packages. Basic skills in creating hypermedia materials as an aid to communicating and to storing and processing information
4. Basic skills in computer input. Currently this is keyboarding, but in the future the emphasis may be on voice input, use of pen-based computer input devices, and effective interaction with virtual reality systems.

B. Deeper knowledge of computers and other information technologies as they relate to the specific disciplines one studies in senior high school. For example, a student taking advanced math courses shall learn about roles of computers in the math being studied. A student taking commercial art courses shall learn about roles of computers in the types of commercial art being studied. A student studying industrial arts should learn about computer-assisted design. A student taking science courses should learn about microcomputer-based laboratories and computer simulations in science.

CEG2 **Computer-assisted learning.** Schools shall use computer-assisted learning (CAL), when it's pedagogically and economically sound, to increase student learning and to broaden the range of learning opportunities. CAL includes drill and practice, tutorials, simulations, and microworlds. It also includes computer-managed instruction (see C. below). Eventually, CAL will include virtual realities designed for instructional purposes. CAL can contribute to MS2-MS11 and of course should not violate MS1.

A. All students shall learn both general ideas of how computers can be used as an aid to learning and specific ideas on how CAL can be useful to them. They shall become experienced users of CAL systems. The intent is to focus on learning to learn, being responsible for one's own learning, and being a lifelong learner. Students have their own learning styles, so different types of CAL will fit different students to greater or lesser degrees.

B. In situations in which CAL is a cost-effective and educationally sound aid to student learning or to overall learning opportunities, CAL shall be used if possible. For example, CAL can help some students learn certain types of material significantly faster than conventional instructional techniques can. Such students should have the opportunity to use CAL as one aid to learning. In addition, CAL can be used to provide educational opportunities that might not otherwise be available. A school can expand its curriculum by delivering some courses largely via CAL.

C. Computer-managed instruction (CMI) includes record keeping, diagnostic testing, and prescriptive guides as to what to study and in what order. This type of software is useful to both students and teachers. Students should have the opportunity to track their own progress in school and to see the rationale for work they are doing. CMI can reduce busywork. When CMI is a cost-effective and instructionally sound aid to staff and students, they shall have this aid. CMI can support MS1, MS2, MS5, MS6, and MS11.

CEG3 **Distance Education.** Telecommunications, CAL, and other electronic aids are the foundation for an increasingly sophisticated distance education system. Schools shall use distance education, when it's pedagogically and economically sound, to increase student leaning.

Note that in many cases distance education may be combined with CAL, so that there is not a clear dividing line between these two approaches to education. In both cases students are given an increased range of learning opportunities. The education may take place at a time and place that is convenient to the student, rather than being dictated by the traditional course schedule of a school.

CEG4 **Applications: Computer-as-tool.** The use of computer applications as a general-purpose aid to problem solving using word processor, database, graphics, spreadsheet, and other general purpose application packages, shall be integrated throughout the curriculum. This is called computer-integrated instruction, or CII. (This relates to MS5-MS9 and MS11. Depending on the process used, CII can also facilitate the other MSs) The intent here is that students shall receive specific instruction in each of these tools, probably before completing elementary school. The middle school or junior high school curriculum, as well as the high school curriculum, shall assume knowledge of these tools and shall include specific additional instruction in their use. Throughout secondary school, students shall be expected to make regular use of these tools, and teachers shall structure their curriculum and assignments to take advantage of and to add to student knowledge of computer-as-tool.

CEG5 **Information technology courses.** A high school shall provide both of the following "more advanced" tracks of computer-related coursework. (These are based on MS8, MS9, and MS11.)

A. Computer-related coursework preparing a student who will seek employment immediately upon leaving school. For example, a high school business curriculum shall prepare students for entry-level employment in a computerized business office. A graphic arts curriculum should prepare students to be productive in use of a wide range of computer-based graphic arts facilities.

B. Computer science coursework, including computer programming, designed to give students a college-preparation type of solid introduction to the discipline of computer science.

CEG6 **Staff support.** The professional education staff shall have computers to increase their productivity, to make it easier for them to accomplish their duties, and to support their computer-oriented growth. Every school district shall provide for staff development, and particular attention shall be paid to staff development needed to accomplish CEG1-CEG4 given above. (This goal supports staff activities needed to effect MS2-MS11.)

This means, for example, that all teachers shall be provided with access to computerized data banks, word processors, presentation graphics software, computerized gradebooks, telecommunications packages, and other application software that teachers have found useful in increasing their productivity and job satisfaction. Computer-based communication is becoming an avenue for teachers to share professional information. Every teacher should have telecommunications and desktop presentation facilities in the classroom. Computer-managed instruction (CMI) can help the teacher by providing diagnostic testing and prescription, access to item data banks, and aids to preparing individual educational plans. The use of computers to help prepare individual educational plans (IEPs) for special education students, now common, provides an example of computer aid for teachers.

CG **Long-term commitment.** The school district shall institutionalize computers in schools. Instructional computing shall be integrated into job descriptions, ongoing budgets, planning, staff development, work assignments, and so on. The school district shall fully accept that "computers are here to stay" as an integral part of an Information Age school system. (This goal supports MS1-MS11.)

As indicated, each of the CEGs can be related to the student-oriented mission statements. Perhaps the best way to summarize this is to point to the last mission statement, MS11: Technology. Students who are currently in school will spend their adult lives in the Information Age or what comes after the Information Age, with ever-increasing involvement with computer-related technology. The CEGs form the foundations for moving our schools into the Information Age.

A school-level TC has the opportunity to influence the mission and goals of an individual school. A district-level TC has the opportunity to influence the mission and goals of a school district. If the school and district goals adequately reflect the CEGs discussed in this section, then the TCs have a firm foundation upon which to do their work. In essence, such CEGs constitute a built-in needs assessment for facilities acquisition, staff development, and curriculum reform.

Orientation of This Book

Most school districts now offer a wide variety of computer-related courses or units of study and are making increasing use of computer-assisted learning. The use of computer-as-tool is now widely accepted and increasingly is set as a goal for all students and as the dominant long term goal. It has become clear that nearly all teachers will eventually need to have some involvement with computers. Out of this overall growth and planning have emerged three general categories of educators seriously involved with instructional computing.

1. The regular classroom teacher of non-computer topics—the computer-using educator. Library media specialists also fall into this category.
2. The computer teacher. This person may teach computer applications, computer literacy, computer programming, and computer science.
3. The TC.

The regular (non-computer) classroom teacher must cope with students who are becoming increasingly computer literate. The teacher must deal with the computer as an aid to instruction and the computer as a tool of both students and teachers.

In many elementary schools the regular classroom teacher may also be expected to provide the initial computer instruction to students. Such teachers may be expected to provide introductory instruction in keyboarding, use of computer-assisted learning materials, word processing, and perhaps even in use of Logo or a hypermedia programming language.

In secondary schools, the regular classroom teacher must routinely work with students who are functionally computer literate. This teacher must extend the students' knowledge and skills in using computer related technology as an aid to knowing the discipline and solving the problems in the discipline the teacher is responsible for.

Because most teachers did not grow up in a computer rich environment or attend schools that provided a computer rich environment, most teachers are ill prepared to deal with such technology. That is, most teachers are woefully unprepared to help students become functionally computer literate.

In many school districts, there are a number of computer teachers. Some elementary schools now have a computer teacher, and an increasing number of elementary schools have a person who supervises the computer labs. In some cases this is a certified teacher, and in other cases the lab supervisor is considered to be a technical support person and may not be a certified teacher. At the secondary school level an increasing number of teachers spend half or more of their time teaching computer literacy, computer applications, computer programming, and computer science courses. A few secondary schools even have a computer science department.

This book is specifically concerned with the third category of educators, TCs. Many schools have designated one of their teachers as the school-level TC. This person may also have duties as a non-computer classroom teacher or as a computer teacher. Many school districts have designated a person as district-level TC; this person may have additional duties, such as being the district's curriculum coordinator. Many educational service districts or intermediate educational districts have a TC. A number of states have established technology centers, so a TC may be employed by a technology center.

Thus, a large and growing number of people hold the position (if not the title) of TC at a school, school district, or some other level. An (instructional) technology coordinator should not be confused with the head of administrative data processing. The qualifications needed to be a successful TC are substantially different from those needed to be the head of a school district's administrative data processing computing. Indeed, it is quite unusual for these two positions to be combined and to be simultaneously filled by one person at a school district level. The general ideas presented in this book suggest that such a combining of job responsibilities is likely to be undesirable. However, at a school building level there may well be an overlapping of instructional and administrative computing responsibilities. At this level the dividing line between the two types of duties is often unclear.

Chapters 4 and 7 of this book contain some rather lengthy lists of possible responsibilities of school-level and district-level TCs. These lists are analyzed to provide a rationale for a set of recommendations on the preparation of educators who seek the position of TC. These recommendations can help guide educators who are preparing to hold a TC position or who already hold such a position. Alternatively, the recommendations can help a hiring agency to select a person who is suitably qualified to be a TC.

Concluding Remarks

The demands being placed on our schools are immense. There is a growing awareness that our schools are not adequately accomplishing the goals that many people feel schools should be accomplishing. Thus, there has been increasing demand for school reform and school restructuring. Many of the school reform studies recommend increased emphasis on higher-order cognitive skills and on students learning to make appropriate use of computer-related technology as an aid to problem solving. Thus, over the long run we can expect a steady increase in the amount and sophistication of information technologies being made available to students and teachers.

Schools can become better by better accomplishing their current goals and by accomplishing new goals that are deemed appropriate. It is evident that computer-related technology can play a key role in both cases. The TC is an educational leader, a change agent. Thus, the TC is likely to play a significant role as schools work to cope with recommendations for school reform and school restructuring.

This chapter contains a list of Mission Statements that are acceptable to most school districts. They provide a firm foundation for thinking about school change. This chapter also contains a list of Computer Education Goals. They are related to various parts of the Mission Statements. Ideally, each school and school district would have a long-range plan for computer-related technology. In the absence of a well articulated plan, the CEGs provide a starting point for the TC to develop a job description and for a school or school district to begin the long-range planning process. This long-range planning is important to the orderly improvement of schools through appropriate use of computer-related technology.

The CEGs underlie a major change in our educational system. Accomplishing these goals requires massive amounts of hypermedia hardware, software, and instructional materials. It requires massive amounts of staff development. It requires major changes to the ways in which we assess student progress and measure the accomplishments of our school systems.

Chapter 3

The Need for Technology Coordinators

Many school districts, states, and provinces have made a serious commitment to substantial and increasing instructional use of computers. It is difficult to obtain reliable, current statistics on the number and nature of the pieces of computer equipment in schools, nor their total dollar value. Similar difficulties exist with attempting to inventory the software and support materials used in schools.

However, at the beginning of the 1982-83 school year there was approximately one "student station" (single-user microcomputer and/or terminal to time-shared system) per 125 students in the United States. By the beginning of the 1985-86 school year the number had grown to approximately one work station per 60 students. At the beginning of the 1990-91 school year, there was approximately one computer work station per 20 students, or approximately three times as many as were available five years earlier. At the beginning of the 1991-92 school year, the ratio was approximately one computer work station per 15 students. It seems likely that sometime during the 1992-93 school year the national average of computer work stations in schools will be approximately one per 12 students. This would represent a change by a factor of 10 over a period of approximately 10 years.

The main amount of this computer growth has come through single-user or networked microcomputers. Thus, for the remainder of this book we will use the term microcomputer as synonymous with computer work station.

The past decade was certainly a period of remarkable growth for computer technology in education. The question is, will this rapid growth continue. Here are two points of view. The first may be overly optimistic, while the second may be unduly pessimistic.

1. **(Optimistic)** Many computer education leaders feel that continued long term growth in computer availability for the next 10 to 20 years is inevitable. There are now many schools that have a ratio of one microcomputer per eight students, and there are a few schools with a ratio of one computer per two students. A few projects funded by the private sector have experimented with a ratio of two microcomputers per student—one at school and one at home. It seems likely that 10 years from now there will be many schools that have one microcomputer per two students and quite a few schools with one microcomputer per student. By twenty years from now, one microcomputer per student will be a common situation, and a majority of students will carry a microcomputer with them, much like students now carry books.
2. **(Pessimistic)** Almost all of the microcomputers that are currently in schools have been acquired using "one time only" money. These microcomputers are steadily aging, and in most school districts there are not enough funds in the regular, continuing school budgets to replace the aging machines. With current levels of expenditures, eventually all of the money being spent will need to be used to replace old machines. If average funding continues at current levels, the total number of microcomputers in schools will increase to a ratio of about one per eight to 10 students, and will then hold steady at that level.

In both of these cases, the amount of compute power (the total number of computations per second and the amount of primary storage and secondary storage) available to students will grow steadily as newer, faster computers replace older machines. Over the next decade we can expect that the price to performance ratio of computers will decrease at least by a factor of 10. That is, in current 1992 dollars, a $1,000 computer in the year 2002 will be more than 10 times as fast as the 1992 computer costing $1,000, and it will have a substantially larger memory.

The available computer equipment is not evenly distributed among the grade levels or among school districts. Some school districts have a computer ratio that is twice the national average, while others have a ratio less than half the national average. Some school districts have concentrated their computer equipment into their secondary schools, leaving their elementary schools with relatively inadequate facilities. Others have created computer-assisted learning labs at the elementary school level and put clusters of computers into individual classrooms, providing better facilities than are available in their secondary schools.

For discussion purposes, let us suppose that schools in the United States will achieve an average of one computer per 10 students within the next two years. This means that a typical school of about 500 students will have about 50 microcomputers, while a large school of 1,500 students will have about 150 microcomputers. In a few schools, these computer facilities will be dispersed throughout the school, with many classrooms having one or two microcomputer, or perhaps clusters of four to five machines. In some schools, all of the equipment will be concentrated into computer labs. In a more typical school, there will be single computer classrooms, some classrooms with small clusters of computers, a library containing a cluster of computers, and one or more computer labs. There is a growing movement toward networking of some or all of the computers in a school.

It is obvious that this is a lot of computer equipment. Based just on the sheer amount of hardware and software in schools, one could argue that every school will need one or more TCs. However, it is not just the total quantity of computer equipment in a school or district that determines if a TC is needed. A more important factor is the nature and extent of use of this equipment. For example, suppose a school has 50 identical stand-alone microcomputers, with 25 in a "typing" classroom and 25 in a library. All machines are dedicated either to the teaching of word processing skills or to the use of word processing. The machines used for teaching word processing are under the control of a typing teacher. The machines in the library are under the control of a library-media specialist. In both cases the machines are treated much like typewriters. This school could well feel it does not need a TC.

The above example is one end of a spectrum of computer use. If a microcomputer is used strictly as a stand-alone word processor, and if the word processing software is relatively simple, every teacher and every student can easily learn to deal with the hardware and software. If a machine breaks, it is picked up by the school district repair center and returned after it has been repaired. There is little difference between a typewriter and a simple microcomputer with a simple word processor.

The other end of the spectrum is the classroom equipped for hypermedia and containing a wide range of hardware, software, and learning resource materials. The students and the teacher are all working together to learn to use the facilities. They often create and/or make use of hypermedia documents. The hypermedia classroom becomes still more complex as it is tied into a school, district, and national network. The complex interactions among the hardware and software make it very difficult to tell whether, when something goes wrong, it is due to failure of hardware, software, students, or teacher. Such an environment requires a substantial amount of support from a highly knowledgeable TC.

The networked, hypermedia classroom will prove to be a major challenge to our educational system. To develop and maintain this environment will require:

1. A great deal of teacher training.
2. A great deal of technical support for students and teachers.
3. A great deal of curriculum development.
4. A substantial increase in budget allocations for technology and support of technology.
5. A long transitional period, while both students and teachers learn on the job.

The last statement is particularly important. We know how to mass-produce computer hardware. While it is difficult to mass produce good educational software, we certainly know how to "mass distribute" good software and courseware. However, we do not know how to mass-produce or mass-distribute well qualified teachers. All teachers are capable of learning to use computer-related technology. Given sufficient time and a sufficiently supportive environment, almost all current teachers can learn to deal effectively with computers.

Computer education futurists have long been aware that our educational system is facing a growing crisis in dealing with technology. They have called for changes in preservice teacher training and in inservice education. They have called for orderly growth in the introduction of hardware and software into the schools.

For the March 1984 issue of *The Computing Teacher,* I wrote an editorial titled "The Two-Percent Solution." (See Appendix C) The editorial was an analysis of how a school district might spend two percent of its annual budget in the instructional computing field. It suggested that half of the money might be spent for hardware. A considerable amount would be spent for software and for support staff.

In 1984, a typical school district with 10,000 students had a budget of perhaps $25,000,000 per year, or $2,500 per student. Two percent of this is a half million dollars per year. Annual expenditures in that range certainly justify and support TC positions at the district and school building levels. Somewhat surprisingly, the basic message of the editorial is still valid.

The editorial suggested that over the long run, we may find school districts, spending considerably more than two percent of their budgets in the instructional computing field. We are beginning to see that happen. In addition, school spending per student has increased more rapidly than inflation. In 1991-92 the US national average expenditure per pupil was in excess of $5,000. Thus, a 10,000 student school system that had implemented the two percent solution was spending a million dollars a year to do so. This level of expenditures certainly justifies having a substantial amount of TC support at the district and school levels.

As will be seen later in this book, a school system making substantial instructional use of computers is faced by a number of tasks that might be collectively assigned to a TC. This is true even in a quite small district. The temptation in a small district may be to distribute these tasks to existing personnel, including teachers. But there is quite a difference between the duties that a TC needs to perform and the duties of a typical classroom teacher. That is, different qualifications are needed to satisfactorily perform these two types of jobs. Chapter 4 discusses this issue in more detail.

There is no simple formula as to when a school or school district needs a TC . Rather, one should examine the tasks to be accomplished as computers play an increasingly important role in schools. Some of these tasks will become everyday duties of regular classroom teachers. Other tasks will be assigned to computer teachers, media specialists, technicians, and various school administrators. In most schools and districts, there will remain a large number of other tasks that are best assigned to a TC.

Thus, one would logically expect that the number of people who hold paid positions as TCs would currently be growing relatively rapidly. Unfortunately, that has not been the case in recent years. Tight school budgets in most parts of the country have forced a cutback in TC employment. Many TCs have returned to classroom teaching or left education. Increasingly, classroom teachers are being expected to learn to use quite complex computer and hypermedia facilities in a school environment that does not provide adequate hardware, software, and staff development support. It is evident that this has been and continues to be a major detriment to increased effective use of computers in schools.

Megatrends: Computers in Education

The previous section argued for schools and school districts having TCs because of the growing dollar value of the computer-related equipment in the schools. This section takes a different approach. It analyzes major changes going on in our schools—it attempts to predict the future—and uses these projections to argue the need for more TCs.

John Naisbitt is well known for his discussions on "Megatrends" that are shaping our society (Naisbitt, 1982; Naisbitt and Aburdene, 1990). In winter term 1990, these books inspired my Doctoral Seminar: Instructional Systems Technology to explore the general topics of Megatrends in Computer Related Technology in Education. This section summarizes some of the work that was done by the class.

Mary Anderson, Ron Gerton, Barbara Kushan, Cynthia Landeen, David Moursund, Sueng-bae Park, Reynold Redekopp, Jeff White-Ferguson, and Leigh Zeitz each made significant contributions to the project. Additional input was provided by students in a doctoral seminar being conducted by Professor Gary Bitter at Arizona State University. I have updated some of the ideas during the past two years.

According to Naisbitt, the Information Age officially began in 1956 in the United States. In that year the number of white collar workers first exceeded the number of blue collar workers. Roughly speaking, white collar workers work with information and/or provide services as opposed to manufacturing products. Teachers, bank tellers, fast food servers, and grocery store clerks are all considered to be white collar workers.

For a historical perspective, note that the number of farm workers in the United States has declined from being about 90% of the work force in 1776 (when the Revolutionary War was beginning) to about 50% in 1876 to less than 3% now. The number of blue collar workers in the United States peaked at about 55% of the work force after World War II, and is now less that 20% of the work force. The trend toward more white collar jobs and less blue collar jobs is still continuing.

According to Naisbitt, a megatrend is a very major trend that is already established and that is likely to have a significant and continuing impact during the coming decade or longer. Naisbitt identifies megatrends through content analysis of periodical publications such as newspapers. He is assisted by a staff that culls through and classifies many thousands of articles each year.

The Doctoral Seminar participants did their initial work through a whole-class brainstorming session. This was followed by the individual class members thinking about possible megatrends, several whole-class group discussions, and individual class members conducting discussions with a variety of people. Next, the participants conducted individual research to gather evidence to help support the general trends listed in the remainder of this section. One approach to gathering this evidence could have been via a formal research study. However, time and resources did not permit this.

Thus, the class decided to take a more informal approach. Evidence was gathered through a number of sources, such as:

1. An analysis of the literature designed to find trends of increasing number of research publications in a specific area and specific articles suggesting the area is of increasing interest and importance.
2. Discussions with colleagues.
3. Analysis and synthesis of the literature and ideas that the individual class members have encountered during their graduate studies and their work as educators.
4. Class discussions on how the varying components seem to be fitting together as individual class members worked on their assigned individual components.

This work produced the following list of nine megatrends in the field of computers in education. While the work of the class focused on education within the United States and Canada, similar megatrends will likely occur in other educational systems in other parts of the world.

1. There will be continued rapid progress in improving student and teacher access to technology to support learning and teaching. Key areas of progress we can expect during the next decade include:
   A. Much better human-machine interfaces, including voice input and pen-based systems. It will be easier to interact with computers. (A "virtual reality" is an example of a much improved human-machine interface system.)
   B. Much more availability of computer-related facilities, including easily portable equipment. Many students and teachers will have portable computers that are the size of a textbook.
   C. Much more computer access in people's homes. A computerized home entertainment and information retrieval center will become common. In many homes, this will be connected via the telephone system or cable TV system to other entertainment and information sources. Increasingly, the connection will be via fiber optic, thus supporting interactive video.
2. In the area of telecommunications, electronic networking, and access to information we will see major increases in:
   A. Telecommunication (electronic mail; access to online databases; Fax). Computers will be networked at the school, school district, and state level. Increasingly, students and educators will telecommunicate across state and national boundaries.
   B. Computerized libraries. The concept of library-as-building or library-as-place will gradually disappear as more and more information is stored electronically and accessed from remote locations. The storage capacity of hard drives, CD-ROMs, and other bulk storage devices will continue to grow rapidly. Thus, the contents of personal libraries will grow very rapidly.
   C. Administrative support (Information Resource Management) systems. Administrative and instructional systems will interact with each other. The school and school district Information Resource Manager will play an increasing role in working with both instructional and administrative computer systems. The dividing line between such systems will blur.
3. In the area of computer-integrated instruction, using the computer as tool, integrating software into the curriculum will occur in three broad categories: generic productivity tools, subject-specific tools, and learner-centered tools. All three types of use will grow rapidly during the coming decade.

A. Generic tools. These are general purpose tools that can be used in many different disciplines. At the elementary and middle school levels students will learn to use word processor, database, computer graphic, and other interdisciplinary tools. At all grade levels there will be an increased use of hypermedia, from desktop publishing and desktop presentation, to sound, graphics, and animation in everyday student projects. This will be accompanied by a proliferation of various templates upon which students can build, so that they will not have to start from scratch with each project.

B. Subject specific tools. The professionals in each discipline have developed tools that enhance their productivity. The effective use of these tools generally requires a great deal of subject matter knowledge within the discipline where the tools are to be used. For example, software has been developed that can solve a wide range of algebra problems. However, it takes substantial knowledge of algebra in order to make effective use of this software. The subject specific computer tools will gradually become an integral component of the content of their respective disciplines.

   The general idea here is closely related to research on problem solving indicating that it takes a great deal of domain-specific knowledge in order to be good at solving problems within a particular domain. A computer program can be written that can help an organic chemist to solve problems in organic chemistry. However, the program is of little use to a person who has no formal knowledge of chemistry and specific knowledge of organic chemistry. Additional discussion of domain specificity in problem solving, and its educational implications, can be found in Gardner (1991).

   There is a growing trend toward integrating the use of subject-specific software into the secondary school curriculum. Computer-assisted drawing, desktop publication, and accounting packages are now in common use in many secondary schools.

C. Learner-centered tools. Learner-centered software allows the student substantial freedom to explore and manipulate a hypermedia learning environment. The teacher, individual students, and groups of students work together in this hypermedia environment, often undertaking projects of considerable size that cut across several disciplines. The Logo environment envisioned by Papert (1980) was an early example of learner-centered software. Hypermedia environments such as *HyperCard* for the Macintosh and *LinkWay* for MS-DOS machines provide examples of learner centered tools.

4. Computer-assisted learning (CAL) will become a routine part of the instructional delivery system. It is becoming common to call the large commercial packages of CAL by the name integrated learning system, or ILS. Currently, however, such CAL use is not being effectively integrated into the overall curriculum in most places where it is being used. These systems will increasingly include better computer-managed instruction components and computer-adapted testing components. Computer tools that can aid in problem solving and information retrieval will increasingly be built into the ILSs. That is, the megatrends 3 and 4 will gradually merge.

5. Hypermedia will have an increasing impact on the content and pedagogy of education. Students and teachers will routinely work in a hypermedia learning environment. They will make use of and create hypermedia documents. Students will work on interdisciplinary projects, guided by teams of teachers from the various disciplines.

6. Artificial intelligence, and especially expert systems, will have an increasing impact on the content and pedagogy of education. An expert system is designed to contain some of the knowledge of a human expert or group of human experts in a particular field, and it attempts to solve problems using this knowledge. This means that schools will increasingly be faced with the difficult question: If a computer can solve or help solve a particular category of problems, what should students be learning about solving this category of problems? Because computer capabilities will continue to improve quite rapidly, curriculum attempting to address this question will be in constant flux.
7. Teacher training programs will be increasingly preparing teachers to move into computer-rich learning/teaching environments. Students entering teacher education programs will increasingly have been computer users for many years before they started college. College of Education faculty will become more computer-competent and will increasingly integrate computer use into their courses. The National Council for the Accreditation of Teacher Education (NCATE) and other teacher training accreditation organizations will begin to require that all preservice teachers become computer literate.
8. Distance education and computer-assisted learning will continue to become more cost effective and will cover a wider portion of the overall curriculum. This will support a growth in home schooling. Schools will restructure to better implement research-based innovative ideas for improving education and to better take advantage of the potentials of computer-based technology, distance education, and computer-assisted learning.
9. There will be a growing confusion as to the most appropriate and effective roles that classroom teachers should play in the overall instructional delivery system. The teacher will become less and less "the" source of information and "the" information delivery system. Instead, the successful teacher will be a facilitator, a guide, a mentor, a learner, a role model.

It is not easy to correctly predict the future. Some or all of the megatrends listed above may prove to be incorrect. However, each of the predictions is based on an analysis of a current trend that has been going on for quite a while and that shows strong signs of continuing.

If the predictions prove to be correct, the overall result will be a continued rapid growth in the amount of computer-related facilities in schools. This suggests a continued rapid growth in need for staff development and for providing support staff. It suggests the need for schools and school districts to have TCs.

Concluding Remarks

It is quite likely that computer use in schools will grow quite rapidly for the next several decades. Twenty years from now we might expect that our schools will provide a computer for every student and that the average amount of compute power available to students and teachers will be between 100 and 1,000 times what it is today. There will be immense increases in the quality and quantity of software and courseware materials available. Students will have routine access to CAL and distance education instructional facilities that span the entire curriculum. These changes will have a profound effect on the teaching and learning process.

This rapid increase in electronic technology in schools will require teachers and support staff, such as TCs, to learn a great amount about dealing with such technology. School systems will explore and experiment with a variety of options on how to provide the needed support staff. In some cases they will use TCs who are certified teachers. In other cases they will use technicians who are not certified teachers. In still other cases they will contract with privately owned corporations to provide the needed support services.

It is evident that this continued growth of computer use in schools will require adjustments to the school budget. The 1984 suggestion that a school district allocate two percent of its resources to the instructional use of computers was rather "far out." Even now, most school districts have yet to achieve this level of continuing expenditures. However, the next decade will likely see a number of schools allocating four to five percent of their budgets to such technology.

Chapter 4

Computer Teacher Versus School-Level Technology Coordinator

To understand the position of a TC, one needs some insights into possible job responsibilities of a TC. In this chapter we examine some responsibilities of a school-level TC to help distinguish this position from that of a computer teacher or a (non-computer) classroom teacher. Later, in Chapter 7, we give a list of possible responsibilities of a district-level TC. The two lists overlap, and in a small district a person holding one level of TC position may be expected to perform duties at both levels.

The Accreditation Committee of the International Society for Technology in Education has developed recommendations for the preparation of computer literacy teachers and for a master's degree in computer technology. Details on these recommendations, that have been adopted by the National Council for the Accreditation of Teacher Education (NCATE), are given in (ISTE Accreditation Committee, 1992). It takes a substantial amount of preparation to meet these recommendations. These recommendations also suggest that every teacher should have a foundational background in the computer field. Most colleges of education now require some computer work of all of their preservice teachers. Over time, we can expect that the computer preparation of all new teachers will gradually grow.

In Chapter 2 we considered three categories of educators with possible everyday and deep involvement with instructional use of computers: regular (non-computer) classroom teachers, computer teachers, and TCs. At the school building level, it is quite common that a regular classroom teacher or a computer teacher is also designated as the TC. But the duties and time demands of a classroom teacher or a computer teacher differ substantially from those of a school-level TC.

Any classroom teacher, including a computer teacher, is directly responsible for the instruction of students. A classroom teacher's main duties involve interacting with students. This requires detailed knowledge of the curriculum to be taught, and it requires good classroom teaching skills.

For example, consider an elementary school computer teacher. Such a teacher may be responsible for teaching an introduction to computers, keyboarding skills, computer applications, and computer programming to every student in the school. This requires developing a detailed scope and sequence, including daily lesson plans, for what is to be taught at each grade level. It requires working with a wide range of students, and it may require working with several hundred different students during a single week. It requires keeping detailed records on the progress of each of these students.

Or consider the person who is responsible for teaching the full range of secondary school computer courses. This could well include teaching an Advanced Placement course using Pascal; several other computer programming courses such as BASIC, C, and Logo; computer application courses; and computer literacy courses. Adequate technical preparation for such a range of teaching responsibilities may require roughly the equivalent of a bachelor's degree in computer science. A high level of skill in understanding and teaching structured programming and problem solving is essential.

Possible Duties of a School-Level TC

Now compare this with some possible duties of a school-level TC. A full time school-level TC might be expected to accomplish most of the tasks given in the following list. A regular classroom teacher with no release time to do TC work cannot reasonably be expected to spend substantial time performing duties on the list in addition to teaching duties.

1. Provide timely help to teachers and students who are having problems with the computer system. This requirement, all by itself, nearly precludes a person being able to simultaneously fill the roles of teacher and TC.
2. Work with a district-level TC and school-level TCs from other schools in the district to do long-range planning, to set district and school goals for instructional use of computers, and to develop detailed computer-related instructional objectives.
3. Address and help solve articulation issues. Students leaving each grade level need computer-related preparation that fits the expectations of teachers at the next grade level. This means, for example, that students leaving an elementary school must have computer-related preparation that meets the expectations of the middle school or junior high school that they will attend.
4. Work with teachers and curriculum leaders to develop specific school-level short term and long-range plans on how to implement the computer-related goals and instructional objectives. Even if each school in a district has the same computer-related goals, there will be many implementation details that vary from school to school. This is because both the teachers and the students vary from school to school.
5. Help teachers to develop curriculum materials and specific lesson plans so that the teachers can carry out their part of the overall school's instructional computing plan. Help to coordinate and articulate the individual teacher's activities so they are consistent with and supportive of the overall school plan.
6. Provide informal and perhaps formal computer-oriented inservice education to teachers and school administrators. Train volunteers, paid aides, and some students to be lab assistants. Provide education for parents and other interested adults. Periodically organize a computer open house for parents, perhaps with all of the demonstrations and instruction being done by students; this might be done in conjunction with a fund-raising effort.
7. Be responsible for the school's computer hardware, software, and support materials. This may include acquisition and maintenance of hardware and software, cataloging and checking out software, scheduling and supervising the computer lab, ordering books and periodicals, and so on. Be in charge of the school's computer network system(s). Maintain the network system and do the needed daily and weekly backups. Be the person who has overall responsibility that a school is not violating software and other hypermedia copyright laws. Carry out or supervise the carrying out of more mundane activities such as dusting the equipment, putting paper into printers, changing laser printer cartridges, and changing printer ribbons.
8. Be responsible for the school's computer budget. Prepare and present arguments to budgeting authorities for increasing the budget. Do grant writing and/or participate in other fund-raising activities.
9. Be a resource person, able to respond to a wide range of questions about hardware, software, and computer applications in education. Maintain contact with sources of information and/or help, such as computer teachers, TCs, computer-oriented

professional organizations and vendors. Keep up on new software; bring this new software to the attention of teachers who might use it.

10. Help students, both in a one-on-one basis and in a classroom setting. Here we distinguish between a computer teacher and the TC who does demonstration teaching or occasionally presents a new product or idea to whole classes. A TC does classroom demonstrations occasionally, while a computer teacher does this regularly.
11. Develop and implement evaluation procedures to assess the overall effectiveness of a school's instructional computing program; make periodic reports on the status and progress of instructional computing in the school.
12. Work with school non-teaching and administrative personnel to help them learn to make effective use of computer technology in doing their jobs. A large school may have an Information Resource Manager (an IRM) who is responsible for this type of administrative computing duties. In such a school, the TC must coordinate with and perhaps assist the IRM. In a small school, the TC may also be the IRM. The TC and the IRM may work together on tasks such as computerization of the school library, tying the school library into district, regional, and national libraries, etc.
13. Keep up in the computer field by studying, attending conferences, and working with new pieces of hardware and software. Develop and follow a plan for personal professional growth.

Quite a few of the above duties fall into the general category of being a computer facilities manager or director. Such positions have existed in college and university education for many years. They are usually filled by people who have held faculty positions and have moved their careers in an administrative direction. This may prove to be a common pattern in schools, but it is still too early to say. Certainly it is a distinct possibility, as more and more schools establish multiple computer labs.

Our educational system has not yet settled on the staff levels needed for computer labs in schools. Also, it has not yet settled on the nature of the staffing that is required. For example, is it most appropriate to staff a computer lab using students, parent volunteers, aides, technicians who are not certified teachers, certified teachers, or certified teachers who have received extensive preparation in the computer field? All of these ideas are being tried out.

In summary, the school-level TC can be seen to have four general categories of duties. These are working as a computer facilities manager, working with school administrators and district-level educators, working with teachers, and working with students. The latter activity is often a modest part of the TC's duties. As compared to a computer teacher, this difference in responsibilities and everyday activities is clear.

More Details on the School TC Job

There are many types of questions and problems that a school TC may encounter. A wide range of knowledge and skill is required. The following list is intended to give the flavor of the types of knowledge and skills that a school-level TC might need to have. One way to think about this list is to imagine that you are interviewing for a position as a school TC. Each of the people interviewing you has studied the following list. Each interviewer randomly selects a topic and develops a question designed to test your knowledge and skills in that topic area. How well would you do? Many of the topics listed include sample questions.

General Knowledge

1. Give a brief overview of the overall field of computers in education that focuses on administrative, instructional, and research uses. Discuss what roles you feel a TC should play in supporting the administrative and research computing needs of a school. For example, should the instructional TC in a school be responsible for helping the school secretaries learn to use computers? Should the TC help the principal learn to use the district's administrative computer and telecommunications system?

   Give a more detailed overview of the field of computers in instruction, including the ideas of Computer-Assisted Learning, Computer-Integrated Instruction, and Computer as Object of Study. Include an historical perspective that gives insights into major trends in each of the three components of instructional use of computers. Which of the three areas seems most important to you, and why?

2. Give a brief overview of computers in problem solving and the teaching/learning of higher-order cognitive processes. Is there software that will teach higher-order cognitive skills? Give several general examples of types of problems that computers can solve and of types of problems that computers cannot solve. If a computer can solve or help solve a type of problem that we are currently teaching students to solve "by hand," what should schools do about this?

The Job

3. Possible duties. Give a brief description of some of the major types of things that a TC might do, along with estimates of how much time per week it might take to do each of these.

4. How can the TC job be structured to fit into the available time? What will you do if the demands of the job exceed the time available? What are the most important tasks that you feel a TC should accomplish?

5. Possible benefits. Give a brief description of some of the "perks" the TC might receive. Discuss the value of each of the following.

   - Extra pay and/or an extended contract.
   - Release time; release from "less productive" duties such as playground supervision or hall duty.
   - An aide.
   - Better computer facilities than are available to teachers in the school.
   - Money to attend a conference.
   - Training.
   - Special recognition.

6. What are the qualifications needed to do the TC job well? Are there trade-offs among the various qualifications? What is your area of greatest strength? What is your area of least strength? What are you doing or what do you intend to do to remedy this relative weakness?

   Do you feel that a TC needs to be skilled at writing computer programs? If yes, what programming language do you feel is most important for a TC to know, and why? If no, discuss the general idea of embedded programming languages in database systems, and/or macros in a variety of computer applications.

7. Personal growth. A TC needs to have a plan for learning more, for getting better at doing the job. How does holding this position fit in with your career goals? Do you feel that the need for a TC will disappear in a few years, or that the need will continue indefinitely? What are some areas that you would particularly like to learn more about in the next two years?

8. Case studies of successful and unsuccessful TCs. What works, and why does it work? What doesn't work? Give examples from your own personal experiences, or from experiences of people that you know.

Needs Assessment and Planning

The following topics may be part of the job responsibilities of a TC. Discuss each topic, and indicate your preparation and experience in carrying out such needs assessment and planning activities.

9. Facilitating and helping to conduct program assessment and/or needs assessment. What is the current status of the computer-in-education activity in the school? What are the perceived needs of teachers, school administrators, parents, students, and others? How do you do a needs assessment?

10. Facilitating and helping to do planning. Each school needs to have a long-range plan for technology. What are some of the most important goals for computers in schools? Who needs to be involved in doing long-range planning for computers in schools? What are major roles that a TC should play in developing and implementing a long-range plan?

11. Developing and maintaining a human resources inventory. How can you determine the current computer-related knowledge, capabilities, and interests of the teachers in your school and help each develop a personal plan for computer-related growth? How would you go about developing and maintaining a list of places where teachers can get additional training and experience?

Staffing and Other Resources

The following topics may be part of the job responsibilities of a TC. Discuss each topic, and indicate your preparation and experience in carrying out staff development and resource acquisition activities.

12. Organizing and helping to conduct staff development. Discuss your experience in doing small group or one-on-one inservice. Discuss the relative merits of group inservice versus one-on-one inservice for helping teachers learn to make effective use of computers in their everyday teaching or for their personal productivity. Discuss effective ways to work in another teacher's classroom. What are some good ways to get teachers to begin doing peer coaching, coming into each other's classrooms to help each other learn to make more effective use of computer-related technology?

13. Forming a school computer advisory committee. Discuss advantages and disadvantages in having a computer advisory committee. Who are the key stakeholders who should be represented on a computer advisory committee? What can you do to get their involvement in both planning and implementation of computer-related technology in the school?

14. Organizing and training volunteers, both students and adults. Is it an effective use of the TC's time to recruit and train volunteers, or are they more trouble then they are worth?

15. Fund raising, such as getting money from the PTA or PTO, and writing proposals to funding agencies. What are alternative sources of funds, and how does one go about

acquiring such funds? What are the costs, in terms of time and effort, in attempting to obtain such funds? Do you feel that a TC should be involved in fund raising?

16. Making effective use of other sources of help. For example, the school library media person (assuming this is not the person designated as the TC) can be very helpful. Discuss the major types of staff in a school and what tasks related to computers in education each might perform. How would you go about gaining their increased levels of involvement?

17. Being aware of and making effective use of other sources of information. What information sources about computers do TCs, teachers, and students need? What is your experience in building and maintaining a resource collection to support the needs of TCs, teachers, and students? What level of budget is needed for this endeavor?

Dealing With Hardware and Software

The following topics may be part of the job responsibilities of a TC. Discuss each topic, and indicate your preparation and experience in carrying out such hardware and software activities.

18. Software. Discuss your knowledge and experience in evaluating, acquiring, and organizing a software collection. How should a school handle tasks such as cataloging, storing, backing up, and checking out software? How can the schools and the school district effectively share the total collection of software that they have acquired?

19. The software copyright and patent laws, and computer ethics. What are the "fair use" rules? What are appropriate and effective ways to deal with software and/or hypermedia piracy on the part of students and educators? How would you handle the situation of discovering that much of a school's software collection was pirated?

20. Hardware. Hardware selection and evaluation; installation and maintenance of a network. What are the advantages, disadvantages, and costs of having school, district, regional, and national networks that students and teachers can use? Discuss your experience in scheduling use of and access to the computer facilities, preventative maintenance, and doing minor repairs. How do you tell that you need help, and where do you get help?

21. Networking. Discuss advantages and disadvantages of networking a school's and a school district's computer facilities. What are some of the technical demands on the TC and on the users of such networks? What is your estimate of the number of hours per week it would take to maintain a school local area network with 50 or 100 microcomputers and a variety of shared peripherals?

22. Design of a computer lab. Discuss needed physical arrangements and ergonomics of a computer lab. What are advantages and disadvantages of placing the school's computers in a lab rather than in individual classrooms? As a school's network of computers extends both into classrooms and labs, what responsibilities should individual classroom teachers have in dealing with the network?

23. The one-computer classroom. What are good ways to make effective use of the limited amount of computer hardware and software facilities that the school has available? Discuss the approach of placing one computer in each classroom versus having clusters or a computer lab.

24. Dealing with computer hardware and software vendors. To what extent should you use vendors as a source of advice on what hardware and software to acquire? What

are alternative sources of advice? Is it appropriate to allow a vendor to buy your lunch or pay your way to visit a school site?

Working With Key Groups of People

The TC needs to work with a number of different individuals and groups of people. For each of the following topics, indicate your preparation, experience, and major ideas on how to accomplish the task.

25. Working with other school TCs and the district TC. How can you cut down on the total work by appropriate sharing with people from other schools and the district headquarters? How would you go about developing a support system of people who can help you do the TC work? What parts of the school TC work can be carried out by the district TC, and vice versa?
26. Working with the school administrators. What support do you expect from school and district administrators? Do you expect to meet regularly with these administrators as you do your TC work? What should a school administrator know about the TC task, and how can a school administrator provide the necessary support for the TC to be successful?
27. Working with the teachers. What expectations do you have for other teachers using computers and learning about computers? How do you go about getting other teachers involved in helping students learn to make effective use of computers? Suggest some ways to get other teachers to take over part of your work. How do you keep teachers from becoming overly dependent on your services?
28. Working with other school personnel, such as secretaries and aides. Should the TC help to train secretaries to make effective use of computers to do administrative and clerical tasks?
29. How to be an effective change agent and an effective leader. Discuss change processes in education. How will education be better as a consequence of your TC work? What evidence do you have to support your claims?
30. Budgeting, purchasing, dealing with fiscal matters. The typical computer facilitator may have a budget, but little or no experience in dealing with money in a school setting. Discuss your budgeting and money handling experiences. What level of budget is needed to carry out the TC activities and for the school to have an effective program of using computer-related technology?
31. "Perks" for the teachers in your school who learn to make effective use of computers in their classrooms. What are some things that might motivate an individual classroom teacher to learn more about computer-related technology and to make increased use of this knowledge in the classroom? Is it appropriate to single out "early adopters" and facilitate their making increased use of computers by providing them more help and computer facilities than are available to other teachers?
32. Making arrangements so that teachers can take home hardware and software over vacations. Discuss the general framework of a school or district policy that would provide teachers with computer hardware and software to use over vacations. What are some of the risks involved, and how can these risks be minimized?
33. Multiple demands on your time. How do you deal with the computer problems that arise elsewhere in a school when, at the same time, you are teaching your own group of students or teachers? More generally, how do you cope with multiple, simultaneous demands for your expertise?

Other Major Application Areas

Here are some additional general topics that a TC might have to deal with.

34. Understanding of roles of computers in a school library and in the field of information storage and retrieval. Should the TC be responsible for computerizing the school library? What roles can a computerized school library play in a school's overall computer plan? More generally, what is an Information Resource Manager (IRM)? What school-level IRM duties should or could be assigned to a TC?
35. Ideas on multimedia, hypermedia, and what a school could/should be doing in these areas. Examples include the LED overhead projector panel, laser disc system, laser printer, CD-ROM, flat bed scanner, touch pad, video camera, and so on. How important is it that students be given the opportunity to work with multimedia and with hypermedia? What level of facilities and of teacher training are needed to facilitate students working with multimedia and hypermedia in the ordinary classroom?
36. Where can one find some sample lesson plans of "really good" computer applications at various grade levels and in various subject areas? Ultimately, each teacher is responsible for acquiring and developing the lesson plans that will help him or her appropriately integrate computer-related technology into the classroom. The TC needs to have a broad and representative sample of excellent lesson plans to serve as models to individual teachers. Discuss your experience in developing such lesson plans.
37. Desktop publishing. Discuss your experience in putting out a school newspaper or in working with school administrators to help meet their desktop publishing needs. What is the role of the TC in moving the school toward making effective use of desktop publishing?
38. Desktop presentation. What is the role of the TC in moving teachers toward making increased and more effective use of the LED overhead projector panel, laser discs, and other computer-related presentation media?
39. Organizing and running a school computer club. Is it the TC's responsibility to organize and run a school computer club? What roles might such a club play in accomplishing the overall computer-related school goals?

It seems clear that the job of TC is complex and demanding. It requires both technical skills and "people" skills. It requires a knowledge of teachers and of schools. It requires versatility and flexibility.

One standard approach to acquiring the necessary knowledge and skills to be a TC is learning on the job. A successful teacher begins to get interested in computers. The teacher attends computer workshops and computer conferences. The teacher begins to use computers and other computer-related facilities in the classroom. Soon, other teachers begin to seek out the advice of the computer-using teacher. Little by little, the computer-using teacher becomes a TC.

As more and more TC duties are placed on this teacher, stress levels increase. The possibility of burnout increases. Eventually the computer-using teacher attempts to obtain release time, increased pay, or other benefits to support doing the TC work. In an appropriate supportive atmosphere, the computer-using teacher becomes a successful TC. In other environments, the potential TC decides that other career paths are more rewarding.

Preparation to be a Secondary School Computer Teacher

It is often argued that a TC should have essentially the same preparation as a computer teacher. Certainly, in many secondary schools the computer teacher may also be the TC. This section contains a brief analysis of the type of preparation needed to be a secondary school computer teacher. It argues that the preparation to be a computer teacher may not be that needed to be a TC.

The secondary school computer teacher might teach a variety of computer science and computer programming courses, including a college preparation or Advanced Placement (Pascal) course. This teacher might also teach a wide range of computer applications courses and/or computer literacy courses. Thus, the computer teacher needs to have a wide range of computer-related knowledge and skills.

The preparation to be a secondary school computer teacher can be divided into three main parts. First, there is the subject matter area. A computer teacher needs to be competent in the field of computer and information science. Second, there are the application areas. A computer teacher needs to have a good working knowledge of a wide range of computer application packages and be prepared to deal with the wide range of topics in a computer literacy course. Third, there is pedagogy. The computer teacher needs to be skilled in teaching computer science, computer programming, computer applications, and computer literacy courses.

A variety of groups have studied the issue of teacher certification to be a computer teacher. A number of states have certification requirements. Sometimes the requirements are just a specific number of credit hours of computer coursework. In other cases the requirements are more stringent—such as the first three years of an undergraduate degree program in the field of computer and information science. Certainly it is necessary to be competent in the subject matter area. In many academic areas such as math and English, a bachelor's degree in the subject area is required for certification. Thus, it is not unreasonable to expect that a computer teacher would have at least the first three years of a degree program in the field of computer and information science.

During the first three years of undergraduate coursework, a computer and information science major is apt to take a year of calculus, a year of discrete mathematics, and three full year sequences in computer science. The first year sequence covers an introduction to computer science, problem solving in a computer environment, and structured programming in two languages. One will be a structured language such as Pascal (or Modula-2) and the other may be a list processing language such as Schema or Lisp. The second year sequence includes data structure, computer organization and architecture, and analysis of algorithms. The third year sequence might be selected from coursework in application topics such as databases or information retrieval, telecommunications, computer graphics, computer simulations, and artificial intelligence. Each of the latter list of topics might be a semester-length course. While these are application-oriented courses, the goal is to cover the underlying theories in each area.

Interestingly, in all of this a student might not encounter any of the applications software used at the precollege level. In addition, if Modula-2 is used in the freshman year, the student might not encounter any of the three languages—BASIC, Logo, and Pascal—that are currently most commonly used at the precollege level. Thus, even a full bachelor's degree in the field of computer and information science may not adequately prepare a teacher to deal with the content of secondary school computer application and computer literacy courses.

The preparation to become a secondary school computer teacher needs to include substantial study of some of the major computer application packages used at that level.

This might include work with integrated packages, desktop publication packages, graphics, spreadsheets, databases, and so on. It must also include study of the wide range of topics that might be included in a computer literacy course. All of this is in addition to the coursework in a computer and information science degree program.

There is also the difficulty of learning teaching methods. By and large, teachers teach in the manner that they were taught. The teaching of computer and information science at the college level is usually designed to produce professionals in the field. The goals are to graduate students who will go to work as computer systems analysts or who will go to graduate school. The instruction is quite rigorous, often integrating a great deal of mathematics and focusing on the underlying theories of the field. In many such programs of study, well over half of the students who begin the program drop out some place along the way, often during the first year of study. Such an approach to teaching is not appropriate at the precollege level.

It should be clear that it requires a very rigorous program of study to become well prepared to be a secondary school computer teacher. However, an examination of the list of possible school-level TC duties suggests that there are major differences between what a computer teacher does and what a TC does. A person could be a highly competent computer teacher and have little knowledge or skills in many of the TC areas. As a specific example, a computer teacher may have very little knowledge about the design, implementation, and maintenance of a school local area network. A computer teacher might have little knowledge of uses of computers in art, business, journalism, music, and the wide range of other application areas in a school. Thus, while preparation to be a computer teacher and experience in being a computer teacher may be a good starting point to become a TC, such preparation does not guarantee success as a TC.

Concluding Remarks

It should be clear that the job of school TC requires a broad range of knowledge and skills. Some of the knowledge and skills are quite technical. It requires a great deal of quite technical hardware and software knowledge to be the person who handles the day to day problems of a local area network and a huge collection of computer hardware and software. However, a great deal of the requirements are "people" skills. A TC works with a great many different people. The task cannot be successfully accomplished without a high level of skills in dealing with this diverse set of people.

Moreover, the TC job requires a great deal of time. It is not possible to deal with the minute-by-minute computer crises of one's fellow teachers throughout the school while at the same time teaching one's own classes. Also, it is clear that many of the duties of a TC are quite a bit different from the duties of a computer teacher. Thus, it seems clear that a school needs to have a TC with a considerable amount of release time to specifically carry out TC duties.

However, the classroom teacher versus TC issue is often confused by having one person fill both types of positions simultaneously. Currently that is the most common situation in schools that have a designated TC. The responsibilities of being both a TC and a classroom teacher are large. It is difficult to be a well-qualified classroom teacher and it is difficult to be a well-qualified TC. To be both simultaneously is particularly difficult, even if one's teaching assignment is to be a computer teacher. Some release time from teaching responsibilities is essential. Also, it is essential to have a clear specification of one's TC duties. Otherwise one is apt to be severely overworked and face the possibility of burnout.

The thesis of this chapter is that every school that wants to make effective use of computer and hypermedia technology needs one or more designated TCs who have release time from the types of classroom teaching and service activities required of other teachers. Later chapters of this book contain additional discussion on the possible preparation to be a TC and a range of potential duties of a district-level TC.

Chapter 5

Technology Coordinator as Computer-Assisted Learning Specialist

Computer-assisted learning (CAL) and distance education are bringing a new dimension to our schools. Taken together, they empower students as learners and they challenge the traditional role of teachers as the sole source of instruction. This chapter examines CAL and the role of the TC as a CAL coordinator. It also contains a brief discussion of distance education and the TC as a distance education coordinator. An introduction to distance education and an extensive bibliography are given in Schrum (1991).

There are many different stakeholders in an educational system. Parents, educators, school boards, community leaders, legislators, tax payers, and business leaders often place conflicting demands on a school system. Moreover, the overall educational system is far more than just a formal schooling system. The home environment and the community are also major players in a child's education.

Thus, as we examine CAL and distance education, we must do so with realistic expectations of their capabilities and limitations. CAL and distance education have the potential to help improve our educational system, but their overall potential is limited. Education is far more than a specific instructional delivery system. The TC must have a good understanding of our overall educational system and the capabilities and limitations of technology to help improve that system.

Learning and Teaching Theories

Educational researchers have carried out a great many studies on how students learn and on effective teaching practices. In total, this educational research provides substantial information on how to improve education. Many of the key ideas are summarized in U.S. Department of Education (1986) and Gardner (1991).

Unfortunately, it is not easy to inculcate the research-based effective teaching and learning practices into schools or into child rearing. By and large, parents parent in the way they were parented. By and large, teachers teach the way they were taught. Progress in educational research makes its way into our educational system quite slowly—in a time frame measured in decades rather than in years. The pace of change in the Information Age is proving to be a major challenge to our educational system.

Computer-assisted learning can be thought of as an attempt to computerize certain important aspects of the overall learning and teaching process. Good CAL software contains both a model of the learner and an underlying theory of how to help a learner learn. It is flexible, adjusting to the needs of specific learners. It is an implementation of a combination of learning theory and teaching theory.

CAL has its roots in programmed texts and in early non-computer-based teaching machines. Much of the early CAL material was based on a behavioral learning theory. The task or material to be learned is broken into a carefully sequenced set of small steps. The CAL materials guide a student through the sequence, providing feedback and remediation as needed. While most current CAL materials are still strongly behaviorally oriented, ideas from cognitive learning theory are now gaining acceptance. CAL materials designed to foster creativity and to improve problem solving often draw heavily on cognitive learning theory.

CAL has the potential to contribute a great deal to improving education. This is because a CAL system can be incrementally improved over time. The CAL system itself can be used to gather detailed records on the nature and the effectiveness of the instruction that students are obtaining through use of the system. Such continual formative evaluation can serve as the basis for improving the CAL system.

Moreover, knowledge gained through research in behavioral, cognitive, social, and other learning theories can often be incorporated into CAL systems. This can be done more quickly and in a more cost effective manner than via retraining all teachers to make use of the new knowledge. This is a very important idea. A CAL system can be incrementally improved over time through the efforts of a wide range of researchers and practitioners. Incremental improvements to a CAL system can be distributed cheaply and quickly.

The late 1980s and the early 1990s have seen a rapid growth in the number of CAL systems installed in American schools. As suggested in the discussion of megatrends (Chapter 3), it is likely that this growth in use of CAL will continue. Thus, most school and district TCs will need to deal with CAL.

To Improve Education

Teaching and learning are complex activities. We know that all students have a great capacity to learn. We know that the teacher, the subject matter, and the learning environment have varying effects on how rapidly and how well students learn. The learning environment is a combination of in-school and out-of-school components. In particular, the home environment is very important. On average, the educational characteristics of the home environment in America has deteriorated over the past several decades. As indicated in U.S. Department of Education (1991, August), many students do not enter kindergarten and the first grade "ready to learn." This has placed increased pressure on schools.

The diagram given below illustrates some of the complexity of schooling. People wanting to improve education can think about changing the student, the teacher, the subject matter, or the overall educational environment. The environment includes the home and cxommunity, laws and regulations, and a wide range of people such as school administrators, school board members, government officials, and business people. Many people making recommendations for educational reform will focus attention on only one or two aspects of our educational system. However, because all components interact in a complex manner, it is not easy to improve education via a narrowly focused set of changes.

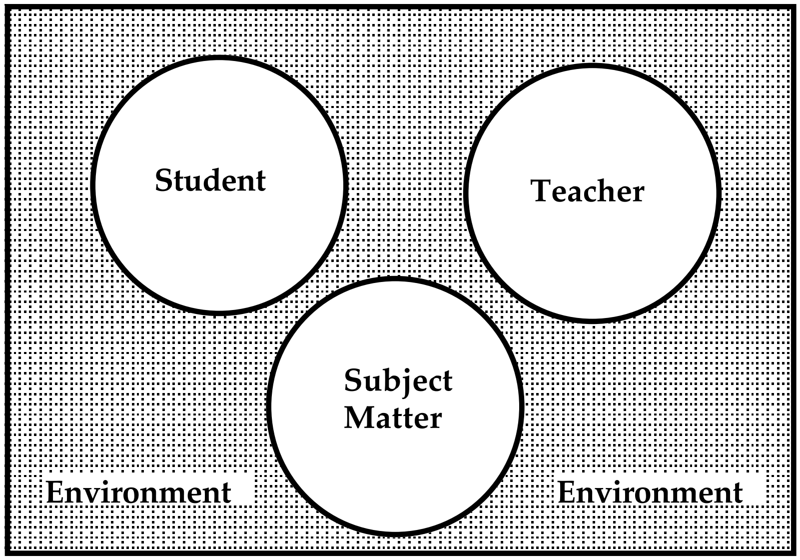


Figure 1. The school environment.

This simple model of learning and teaching suggests a four-pronged attack to improve education. Researchers can carry out research studies on ways to improve the student, the teacher, the subject matter, and the environment. Our educational system can systematically implement the effective practices suggested by these research studies. The work of Slavin (1989) suggests that this rarely occurs. Slavin suggests that our educational system has a propensity to be faddish—to put a lot of effort into implementing changes that are not based on solid research and that generally turn out to be ineffective. He suggests that by the time a particular fad proves to be ineffective, our schools are well along toward implementing the next exciting but unproven fad.

A TC should be a change agent—a leader in educational improvement. There are many research-based ideas on how to improve education. A TC needs to have knowledge of such research so as to compare and contrast potential technology-based changes to education with non-technology-based changes. The TC must realize that there are many non-computer ways to improve education.

Education can be improved by helping students learn how to learn. Teach them study skills. Give them practical implementations of the best results in learning theory, and they will learn better and faster. The use of "chunking" and mnemonics in memorization provide examples. As another example, research has shown that different students have different dominant learning modalities. Some students learn best by seeing; others learn best by hearing or by doing. Students can learn to take advantage of their dominant learning modalities as part of learning how to learn. Howard Gardner (1983) and Gardner & Hatch (1989) suggest that schools also need to pay more attention to the widely varying types of intelligences of individual students. Students need to learn about their relative strengths and how to capitalize on these talents.

Similarly, teachers can learn to make use of ideas from the theory of teaching. A simple example is provided by the idea of "wait time." How long should a teacher wait after asking a question before accepting an answer? Research suggests that the typical teacher doesn't wait long enough.

As another example, how should a teacher introduce a new idea? A new idea can be introduced by using a carefully selected collection of examples and non-examples. Appropriate models of reinforcement can be used to increase learning rates. Review cycles can be better designed by appropriate use of models of forgetting. We can teach for transfer of learning, and students can learn how to increase the transfer that occurs in their learning.

We can carefully examine the subjects to be learned and how this subject matter should be organized. For example, all students need to learn how to write. How much of the subject called "writing" should be devoted to spelling and grammar? Research suggests that in the past we have placed far too much emphasis in those areas. Research into writing has identified that writing can be considered to be a process. Out of this research has come the idea of process writing that is now commonly taught in schools.

Research in math education has led to a conclusion that concrete manipulatives can serve as a foundation for mental models that help students to better understand math. Thus, the math content of the curriculum can be modified to make increased use of manipulatives. Other research into the mathematics curriculum in America suggests that the junior high school and middle school curriculum contain relatively little new content. Math education could be improved by adding new content at those grade levels.

Finally, the overall teaching and learning environment can be studied. Research into Head Start programs strongly supports the effectiveness of improving the home environment. Research into cooperative learning strongly suggests that cooperative learning environments are desirable over a wide range of subject areas. Research into interdisciplinary studies supports the idea of students working on projects that cut across many different subject areas, assisted by teams of teachers who cooperate in the overall design and delivery of instruction.

It is easy to pick out a weak link as our educational system attempts to implement ideas suggested in the above analysis. Most parents parent in the way they were parented, and most teachers tend to teach in the way they were taught. Parents and teachers do not have the time and energy to keep up with research in learning and teaching theory. Consequently, research progress is only slowly translated into improvements in our educational system.

It is often suggested that the desired educational progress can occur by working through the instructional materials and instructional environment. To do this, authors and publishers should incorporate the latest learning and teaching ideas in the books, films, and other instructional materials. Teachers and schools should make use of language labs, equip science labs with the latest scientific instrumentation, and use modern facilities in business practices classrooms. The past several decades have seen substantial efforts to do this. These efforts have titles such as language labs, new math, math manipulatives, teaching machines, and educational television. Textbooks are now much more colorful and entertaining; programmed texts have come and gone.

The difficulty in making a major improvement in our educational system through changing instructional materials and environment is evident if one examines these attempts. Our educational system is massive, and it is massively resistant to change. Federal legislation backed up by substantial funding can help, as is demonstrated by PL 94-142 in the area of special education. But even educational television, which has received considerable funding over the years, has been able to do little to overcome the educational system's resistance to change. Attempts to improve the educational system through designing better textbooks are confronted by realities of the market place. Many major publishers are unwilling to publish really innovative textbooks; many school systems are unwilling to attempt to use really innovative textbooks.

And now, of course, it is suggested that computer-assisted learning is the answer. CAL can be viewed as a combination of media. It has features of books, television, teaching machines, student-controlled manipulatives, and teachers. It has been developed, researched, and implemented over a long time span. Perhaps CAL is powerful enough to allow effective implementation of what is known about the overall learning and teaching process. Many people believe this to be the case and are pushing quite hard for increased use of CAL in our schools. Thus, the TC must interface between the dreams and realities of CAL.

The Integrated Learning System

The history of CAL is nearly as old as the history of computers. By the early 1970s there had been enough research studies into CAL to support the first meta-study in this area. It showed that CAL was a promising vehicle for the delivery of a substantial range of subject matter instruction. There have been a number of meta-studies since then. An overview of the literature and progress through the early 1980s is given in Walker & Hess (1984). More recent literature is summarized in Krendl and Lieberman (1988), Kulik and Kulik (1987), Niemiec and Walberg (1987), and Roblyer (1990).

Perhaps the most important thing to say about CAL is, "It works." Much of the roots of CAL lie in behavioral psychology and the work of Skinner (1984). If the knowledge or skills to be learned can be carefully defined, a behavioristic-oriented sequence of instruction can be developed. Research has repeatedly supported the effectiveness of such instructional sequences. Students learn as well or better, they learn substantially faster, and their attitudes toward the material being learned tend to improve.

Research supports the cost-effectiveness of CAL delivered via microcomputers (Hawley, 1985). Moreover, there is a strong historical trend for computers (hence, CAL) to decline in price, so that CAL gradually becomes more cost effective. If this occurs during a time when the salaries of teachers are increasing, then CAL becomes even more cost effective relative to teacher-delivered instruction.

For about a decade, beginning the early 1960s, the United States government funded substantial research and development in CAL. A number of the current major CAL companies can trace their roots to these federally funded projects. While the original work was done on mainframe or mini computers, in recent years microcomputers have come to dominate CAL. The reader should realize, of course, that many of today's microcomputers are more powerful than the mainframe computers of the early 1960s. Moreover, microcomputers provide a level of graphics and interactivity that far exceeds what was available on early mainframe computer systems.

There are strong opponents to the widespread use of CAL. People who view education as a human endeavor or as an art rather than a science are quite bothered by the rather mechanistic aspects of CAL. They fear that CAL dehumanizes education and the student. They also question whether CAL can be effective in teaching higher-order cognitive processes. Much of the currently available CAL material is strictly drill and practice in nature, and much of it focuses on lower-order cognitive skills.

A number of the major CAL companies refer to their products as Integrated Learning Systems (ILS). Typically an ILS has a very large collection of instructional materials that is stored on a CD-ROM or on a hard disk. Student work stations are networked to a file server. (Alternatively, a stand alone system may make use of a microcomputer and a CD-ROM player.) Often a school or school district acquires an ILS consisting of as many as 32 student work stations. The total cost is approximately $4,000-$5,000 per student work station. This includes hardware, software, installation, and teacher training. Larger school districts often purchase a number of the systems; indeed, there may be a number of these systems installed in a single school.

The increasing power of computer hardware in CAL systems has made it possible for these systems to provide increasingly good computer-as-tool support to their users. It is now common for a wide range of word processor, database, spreadsheet, graphics, and other tools to be built into an ILS. This is a trend that will continue.

During the 1991-92 school year, the average cost of a student in public school in America was about $5,500. Thus, the average cost of an ILS work station was somewhat less than the cost of a year's schooling. In most schools that have an ILS, the typical student uses the ILS for less than a half hour per day. Thus, through careful scheduling, one ILS work station serves 10 or more students. We can expect two major trends in the future. First, the cost of an ILS work station will decrease, especially relative to the overall cost of a year's schooling. Second, on a nationwide basis the average number of minutes per day that students spend at an ILS work station will increase.

Role of the TC

CAL can range from a teacher making use of a simple stand-alone drill and practice program or a simulation on a stand along microcomputer, to a school district installing a number of ILSs. In the former case, the software might cost $29.95 and the teacher might learn to use it with little or no outside help. This is an individual teacher-directed, bottom up approach to use of computers in schools. An individual teacher makes the decision to acquire, learn to use, and use the CAL software.

In the ILS case, a 32-work-station system may have a cost about $120,000-$150,000. This initial cost usually includes maintenance, training, and courseware updates for a specified period of time, such as one or two years. After that, there is a substantial continuing cost for maintenance and updates. The decision to acquire such a system is often made by a superintendent, and the decision making process represents a top-down approach to use of computers in schools. Individual teachers are directed to use the system, and they are usually not involved in the decision to acquire the system.

The proper selection of hardware and software, the development of appropriate supportive curriculum materials, the integration of CAL into the overall instructional delivery system, and the training of teachers to make effective use of CAL are all still quite difficult tasks. There are hardware decisions to be made and hardware to be purchased, housed and maintained. Software decisions need to be made, and software must be purchased, stored and maintained. Teachers need to be trained in effective use of CAL materials. The student use of CAL needs to be integrated into the rest of the overall instructional delivery system. If there is no CAL specialist position, all of these duties may be assigned to a TC.

Distance Education

Distance education existed long before computers and modern telecommunication systems came on the scene. A correspondence course is an example of distance education; here, the interaction between student and teacher is via mail. The general idea of distance education is that the instructor and the student are located in different places. The instruction might be delivered through printed materials, audio tapes, video tapes, radio broadcast, or television broadcast. Some or all of the same vehicles may be used for students to communicate with their instructors. In many cases there is relatively little interaction between the students and the instructor.

In recent years, a range of telecommunications-based distance modalities have been developed. Interaction between instructor and student may be by two-way audio, two-way audio and one-way video, or two-way audio and two-way video. The instruction may be supplemented by books, audio tapes, and video tapes. It may also incorporate CAL. An excellent summary of the key ideas and issues in distance education is given in OTA (1989) and in Dede (1990). It seems evident that the potentials of distance education are greatly improved by modern telecommunications.

Distance education is widely used throughout the world. In England, tens of thousands of students are working for a college degree through the Open University. In China, more than a million students are enrolled in a distance education two-year college degree program. In the United States, more than ten thousand engineers have earned a master's degree through distance education in the National Technical University. Many thousands of students are taking high school courses through distance education; a rapidly growing number of teachers do inservice work through distance education.

Distance education has been extensively researched. For many students, it works as well as does the more conventional, classroom-oriented instructional delivery system. However, it is evident that distance education is not equally suited to the needs of all students. For example, many students require more individual help than can readily be provided through a distance education system.

Both CAL and distance education bring a new dimension to our educational system. First, both can provide instruction in the home or in other non-school environments. As distance education and CAL gain in quality, availability, and acceptance, students will have access to an increased range of learning opportunities. Second, CAL and distance education provide a type of competition to traditional teacher-based instructional delivery. Thus, they may well lead to changes in the teacher's role in the classroom.

One possible role of a TC is to be the school or district expert in CAL and distance education. The CAL and distance education expert can play a leadership role in the acquisition and installation of facilities, teacher training, and curriculum revision. These are challenging tasks!

The Future of CAL and Distance Education

As suggested earlier in this chapter, CAL and distance education bring new dimensions to education. Among them are:

1. Continuing improvement of the materials through ongoing formative evaluation and progress in teaching/learning theory. These incremental improvements, made on a year-to-year basis, can be quickly mass produced and widely distributed. Moreover, because of the frequent updates of CAL materials, it is possible to keep the content of the materials more up to date than is typical for strictly text-based instruction.
2. Empowering students by offering them a much wider range of courses at times that suit their convenience. Many schools currently offer a very narrow range of courses; obviously this range can be greatly increased through CAL and distance education. Indeed, students can use such materials at home.
3. Greater individualization of instruction and greater learner control. Education is improved by providing students aids to learning that are at an appropriate level for their current level of knowledge and skills, and at a time when the students want to learn.
4. Competition. Instruction on a particular topic may be available from a number of sources. Students can have access to courses offered by the world's greatest teachers and/or CAL-based courses that have been put together by a large team of content and pedagogy experts, and then extensively improved using continuing formative evaluation.
5. Cost effectiveness. Distance education and CAL may well be less expensive than a teacher-taught course. There are a variety of indicators that the cost factor is beginning to play a significant role in the decision of whether to use distance education and/or CAL, and how to staff such use. If a student is engaged in studying a course via distance education and/or CAL, does the student need to be supervised

by a certified teacher? Might it suffice to have the student supervised by a teacher's aide or a parent? Or perhaps the student is sufficiently mature to require no adult supervision.

In combination, these characteristics of distance education and CAL will greatly change education and the role of teachers in education. The remainder of this chapter focuses on CAL, but many of the ideas also apply to distance education.

It seems evident that CAL use of computers is in its infancy and that the period of most rapid growth still lies ahead. Schools currently making substantial use of CAL may schedule their students for 10-20 minutes of computer time per day. Over the next 10-15 years we will likely see two phases of change in CAL use. First, the average number of minutes per day of CAL use will increase. This could well lead to many students being scheduled into a CAL lab for 30-50 minutes or more in the morning, and for a similar time period in the afternoon.

In the second phase, CAL and computer-as tool will blend together. The CAL labs will disappear, with the computer facilities being moved into the regular classroom. Students will have routine access to such blended systems throughout the day. They will switch between tool use and CAL use as the need arises.

This second prediction suggests that CAL may prove to be the major vehicle for the eventual integration of computers as an everyday tool in the curriculum. As CAL materials improve, it will become harder and harder to distinguish CAL from computer-as-tool. For example, a program designed to help teach graphing will be able to do graphing. A program to help students learn grammar will be able to determine grammatical errors and make suggestions for changes. A music program for ear training may be useful in musical composition. All teachers know the power of "the teachable moment." When a student has both high interest and need to know, learning occurs very rapidly. Integration of CAL into computer tools will increase student ability to take advantage of teachable moments.

Concluding Remarks

The transition from computer labs to computers being thoroughly integrated into the classroom will not be easy. It is made more difficult by the fact that the technology of CAL is still changing, as can be seen by examining the current status of videodisc-based CAL. Videodisc-based CAL is a melding of computer and television technology; it may also include touch screen, joy stick, mouse or even voice input. While videodisc hardware, software, and courseware are now reasonably priced and fairly reliable, most schools have been slow to adopt the technology. The precollege TC working in this area is still a pioneer and must be a super salesperson. We are all aware of the successes and failures of television as an instructional medium; will videodisc-based CAL go the same way?

Eventually all teachers will learn to cope with CAL and with computer-as-tool thoroughly integrated into CAL materials. They will have used CAL while in school, and they will have studied CAL in their college media and methods courses. As this gradually happens over the next few decades, the role of TCs as CAL specialists will change. But meanwhile this may be one of the major parts of a TC's job.

Chapter 6

Instructional Systems Technology Facilitator as Computer-Integrated Instruction Specialist

Computer-integrated instruction (CII) is the integration of computer applications (computer-as-tool) into the content of the overall school curriculum. Computers are powerful aids to productivity and to problem solving. Thus, tool uses of computers can have a profound impact on the curriculum. The TC may need to be the school or district leader in working to integrate tool uses of computers throughout the curriculum.

Three Types of Tool Uses

As indicated in Chapter 2, CII can be divided into three somewhat overlapping categories: generic tools, subject-specific tools, and learner-centered tools. Depending on point of view and the level of sophistication of the user, a tool such as graphics might be considered to be generic, subject specific, or some place inbetween. The Venn diagram given below is suggestive of this situation.

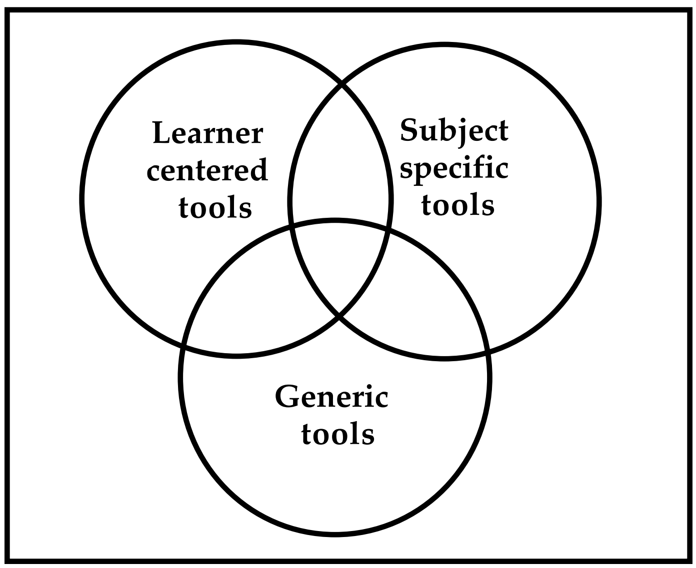


Figure 1. Computer-integrated instruction. (Tool uses of computers.)

1. Generic tools. These are general purpose tools that can be used in many different disciplines. At the elementary and middle school levels, students can learn to use word processor, database, computer graphic, and other interdisciplinary tools. At the middle school or high school level, students can learn to use a spreadsheet and other aids to modeling. At all grade, levels students can learn to make use of presentation media, telecommunications, and online searching of databases.

   A parallel is sometimes drawn between generic computer tools and reading, writing, and arithmetic. Each of the "subjects," reading, writing, and arithmetic, is a discipline in its own right, and all students study these disciplines. But each is a tool useful in studying and learning to attack the problems of practically any academic area. Thus, our school system works hard to ensure that all students develop basic competencies in reading, writing, and arithmetic so that they will have the skills needed to use these tools in all disciplines. Similarly, it is suggested that our schools should ensure that all students learn to make effective use of generic computer tools.

2. Subject-specific tools. The professionals in each discipline have developed a wide range of tools that enhance their productivity. Software for writing music (used in conjunction with music synthesizers) provides an excellent example. The software is designed to increase the productivity of a person writing music. Similarly, desktop publication software has changed the profession of preparing materials in a form so they are ready to go to press.

The effective professional-level use of the subject-specific tools generally requires a great deal of subject-matter knowledge within the discipline where the tools are to be used. For example, software has been developed that can solve a wide range of calculus problems. However, it takes substantial knowledge of calculus in order to make effective use of this software. If you don't know any calculus, you cannot effectively input calculus problems to such a tool and interpret the results produced by the tool.

The general idea here is closely related to research on problem solving indicating that it takes a great deal of domain-specific knowledge in order to be good at solving problems within a particular domain. There is a growing trend toward integrating the use of subject-specific software into the secondary school curriculum. Computer-assisted drawing, desktop publication, and accounting packages are in common use in many secondary schools.

3. Learner-centered tools. Learner-centered software tools support guided discovery learning, where the student, teacher, and software environment work together to enhance learning. The Logo environment envisioned by Papert (1980) was an early example of learner-centered software. Hypermedia environments are a natural extension of Papert's original ideas (Bull, Bull, and Harris, 1990).

Learner-centered software allows the student substantial freedom to explore and manipulate a hypermedia learning environment. The teacher, individual students, and groups of students work together in this hypermedia environment, often undertaking projects of considerable size and that cut across several disciplines. A hypermedia document on a social studies topic such as "Effects of Advertising in Recent National Elections" provides a good example of this type of work. In this project a group of students might gather data over a period of weeks. Their "report" might include tables, graphs, and charts, video, sound, and text.

It is important to realize that tools themselves contribute to the various disciplines. We are gradually moving toward the situation where the computer tools and the disciplines where the tools are used will be so woven together that separation will not be possible.

The Calculator Example

Progress in integrating computers as everyday tools into the overall curriculum has been slow. While some attribute this to a lack of sufficient hardware and appropriate software, the problem is deeper than that. We can see that by examining calculators. A good quality solar battery-powered calculator now retails at under five dollars, which is perhaps a fourth or less than the cost of a textbook. (In 1980 the cost was about $12.) Such a calculator can stand quite a bit of rough handling and will last for years. Indeed, one might compare it with a textbook in these regards.

It would be quite easy for schools to provide all students with excellent access to calculators. Such a course of action has been recommended by the National Council of Teachers of Mathematics and the National Council of Supervisors of Mathematics since 1980. But this has been slow to occur. Only in the late 1980s did we begin to see large school districts such as Chicago, Illinois and Portland, Oregon begin to purchase tens of thousands of calculators for their students. This was fully 10 years after calculator prices had ceased to be a major determining factor in their use.

Even now, there have been relatively few changes to the mathematics curriculum to reflect calculator capabilities. Many students and teachers still consider use of a calculator to be cheating. It might be all right to use a calculator at home, but it is not appropriate to use it on tests in school. The national testing services are still struggling with what to do about calculators. One approach is to design tests where every student is assumed to have essentially the exact same calculator. A second approach is to design tests so that access to a calculator is of no particular value. Both approaches miss the idea of a careful integration of calculators into the very fabric of the curriculum, and the rapid pace of technological change.

The calculator problem will likely be repeated with computers. The current curriculum content is well entrenched. It is supported through the textbook writing and adoption process; teacher, parent, school board and administrative knowledge; curriculum materials; and standardized tests. Often the initial argument against CII is that there is not adequate and sufficient hardware and software. Certainly that was the initial argument against calculators. But eventually hardware and software will not be the major issue. In some schools that is now the case. As the calculator example illustrates, that does not mean the computer will be integrated into the curriculum. Thus, it seems evident that one responsibility of a TC is to be a leader in computer-integrated instruction.

The school-level TC is in an excellent position to support teachers learning to use computer tools. Moursund (1990b) discusses inservice methods for helping teachers learn to use computer applications. It includes a major emphasis on one-on-one inservice. The school-level TC can interact with a teacher at a teachable moment, when the teacher has need to know how to use a particular computer application. Often a few minutes of personal instruction are enough to get a teacher started.

Another excellent approach to helping teachers learn computer applications is to encourage teachers to help each other. The TC singles out the early adopters—some teachers who are particularly eager to learn computer applications. These teachers are then encouraged to provide one-on-one help to their fellow teachers.

General Discussion of CII

Some computer applications are rather general purpose, such as word processing, computerized information retrieval, and computer graphics. A student who has mastered the use of word processing and graphics will find uses in a number of disciplines. The representation, organization, storage, and retrieval of formation retrieval, is important in every discipline. Graphics are useful in representing key ideas in almost every discipline. But how should instruction in such computer applications be fitted into the overall curriculum, and who should provide the instruction?

The level of CII use in a school needs to be a school district level of decision, as it affects all students and all teachers. For example, suppose that students learn to use a graphics package in the seventh grade. Then all teachers at the seventh grade level and higher should expect their students to make use of a graphics package when it is appropriate to the material being studied. When relevant to what is being taught, each such teacher should encourage use of computer graphics and provide additional examples of appropriate usage. This could occur in a social studies class, an art class, an industrial arts class, a science class, or a mathematics class.

Or consider the growing importance of using computers to store and retrieve information. We currently expect all students to gain basic library skills. Eventually we will expect all students to learn to make computer searches of databases. But it does little good to teach such skills to a seventh grader if no computer access for such purposes is available to the students in later grades. It is a form of hypocrisy to expect students to learn to construct and use computerized databases, when their teachers don't acquire similar knowledge and skills.

The current classical example of a poor approach to CII is provided by many schools' approach to word processing. Many schools are introducing students to word processing in the elementary school grades. This can be done using as little as one or two microcomputers in a classroom. Students receive a little instruction in keyboarding. They may be told to "use both hands; use your left hand on the left side of the keyboard and your right hand on the right side."

But that amount of instruction and a very limited daily access to computers is a severe impediment to the student who wants to write. Many of the students will have a keyboarding speed of perhaps three to five words per minute. That is, most students can print or write in cursive several times as fast as they can type. Being forced to use a computer in this case might decrease a student's desire to write. Moreover, writing is something that one may want to do at any time of the day and in any subject area. Thus, most of a student's writing will still need to be done by hand in this environment.

Contrast this situation with the needs of a serious writer. Most serious users of word processing type faster then they can write. A typing speed of 30 words per minute or more, and the ability to compose at the keyboard, are common. Eventually such writers become highly dependent upon having access to a word processor whenever they want to write. If schools want word processing to be an integral part of the student writing process, they will need to provide substantial formal instruction and opportunity for practice. They will need to allow students access to word processing facilities as they take essay tests.

Computer Literacy for Teachers

The general-purpose computer applications constitute the core of CII. They also constitute one major aspect of computer literacy for teachers. If CII is to become an effective reality, all teachers will need to learn to use computers and to work with students who use computers as tools on a daily basis. All teachers will need to learn to help extend student abilities to make effective use of these tools. This massive inservice education problem falls on the shoulders of TCs.

Other computer application packages, such as spreadsheet or accounting packages, are not as widely applicable in a precollege curriculum. But a spreadsheet provides a good example. A TC needs to make sure that this type of computer application is appropriately integrated into the curriculum. Does it belong in an office practices or other business course? Is it an appropriate topic in a mathematics course? Is a spreadsheet useful in a social studies or science course? The answer may be yes in all cases, and suggests that lack of computer literacy for teachers is a broad based difficulty. This type of difficulty could be addressed by a committee of teachers and curriculum coordinators; it is appropriate that a TC head such a committee.

In recent years the field of computer applications has made very rapid progress. Software is becoming more user friendly; windowed software is used via keyboard, mouse, touch screen, graphics pad, pen-based input, and voice input. Integrated packages allow the easy intercommunication of graphics, word processing, spreadsheet, database, and telecommunications. These are powerful tools, and their integration into the curriculum is not easy. The computer-literate teacher functions comfortably in an environment that includes routine use of these computer facilities.

As a final example, consider the issue of keyboarding. There is considerable agreement that if students are to use computers for such tasks as composition or entering data into databases, formal training in keyboarding is essential. At what grade level should it occur? Who should teach it? How should this instruction fit in with typing and other business skills courses taught in the secondary school? How will instruction in keyboarding affect student progress in spelling and reading? How important is keyboarding as pen-based and voice input systems become cheaper and more readily available? These are typical problems that a district TC faces.

Subject-Specific Tools

Think about learning math, but not learning to use pencil and paper, ruler, compass, and protractor, math tables, or any other aids to doing math. The idea is preposterous! Math, and the tools for doing math, are so intertwined that it makes no sense to separate them.

As computers have become readily available to the professionals in each field, a set of computer tools has been developed in each field. Often these are not general purpose tools, useful across many disciplines. The tools designed to help a professional musician are of little use to an engineer faced by a circuit design or structural analysis problem.

The computer tools that have been designed for the professionals in each discipline greatly increase their productivity. Gradually, these tools are being integrated into the very fabric of the disciplines. This is a major challenge to teachers at all levels. Pity the fifth-grade teacher who is very skilled at teaching paper and pencil long division, and who is told instead to teach problem solving to students who have been using calculators to do long division for several years. Pity the accounting instructor who must teach students to audit books that are fully computerized.

It is not possible for a TC to know the advanced computer tools of each academic discipline. It is the individual responsibility of each teacher to learn to use these tools and to appropriately integrate their use into the disciplines they teach. The TC can perhaps suggest some initial pieces of software to be learned, and can provide encouragement. For example, a TC does not need to be a musician to know that MIDI hardware and software are common in the music profession. A TC does not need to be a graphic artist to be able to name and demonstrate initial use of a range of desktop publishing and graphic arts systems.

Learner-Centered Tools

Logo and a variety of hypertext systems are the best-known examples of learner-centered tools. These have the characteristic that students can easily get started, but that the tools are quite powerful and are difficult to fully master. Logo, for example, is used in primary school and has also been used in the first course taken by college freshmen who are computer science majors.

A similar statement holds for popular hypertext systems such as *HyperCard* for Macintosh computers and *LinkWay* for MS-DOS computers. After a modest number of minutes of instruction, students can learn to create buttons and fields, and to link together text and graphics in a non-linear mode. However, *HyperCard* and *LinkWay* each includes a comprehensive and sophisticated programming language. To "master" one of these hypertext systems, one must master a programming language.

This creates a dilemma for education. Given proper instruction, most students can learn the rudiments of a hypertext system. But this takes considerable time and effort. Thus, if a student invests the needed time and effort, it only makes sense that the student would be allowed and encouraged to use hypertext writing skills in the variety of courses they are taking. However, as students with this type of knowledge progress through the schools, they will find that most of their teachers lack similar skills.

Learner-centered tools are a challenge to the TC. Should all teachers in a school be encouraged to learn to use learner-centered tools? Is this as important as learning to use generic tools and subject-specific tools? At the current time, appropriate answers vary greatly from teacher to teacher and from school to school. Thus, it may well be that one-on-one inservice, designed to meet the individual needs of the teacher, is the most appropriate approach to staff development within a school.

Concluding Remarks

The analysis of CII given in this chapter suggests that a TC must have very broad academic and curriculum skills. The TC must work with teachers and curriculum coordinators in all disciplines and at all levels to plan and implement CII. But the TC needs to be aware that the overall goal is to improve the quality of education. The implementation of CII does not automatically improve the quality of a student's education. The TC must work with evaluators and teachers to determine the effects of CII, and to ensure that appropriate use is being made of computers. The TC must encourage individual teachers to take responsibility for their own computer literacy development.

Chapter 7

The School District Technology Coordinator

The analysis given in the previous chapters suggests a TC may have a wide range of responsibilities. These might be divided into two major categories: planning and implementation. At the individual school level, a TC's job is apt to be highly weighted toward implementation. At a school district level, the TC will tend to spend quite a bit more time on planning and in supporting implementation by the school-based TCs. This chapter focuses on a wide range of possible duties of a school district TC.

Planning

In a school district, planning must be done on the nature and extent of learning/teaching about, using, and integrating computers that will be part of the overall curriculum design. This says that a TC needs to be a curriculum leader—a curriculum generalist who can facilitate change at all levels and in all aspects of the curriculum.

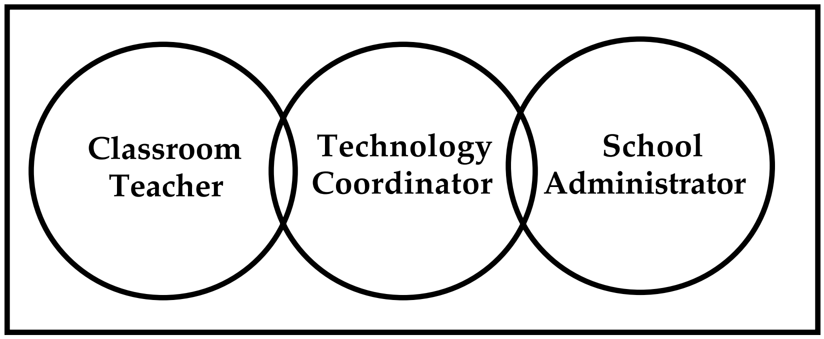
The planning must also take into consideration resources available for implementation. Money is certainly one possible resource, but existing hardware, software and computer-oriented supportive materials are also resources. And people are an essential resource. What computer-related knowledge, skills, and attitudes do the various teachers and administrators have? Are administrators, curriculum coordinators, and department heads able and willing to devote time and energy to implementing instructional uses of computers? Do the school board members and taxpayers support increased instructional use of computers?

A school system has many discretionary resources that might help facilitate instructional computing. Who decides whether the school and district libraries should subscribe to computer-related periodicals or purchase computer-oriented books? Is inservice money available to offer computer-oriented courses? Is travel money available so that some educators can visit schools making good use of computers or so educators can attend computer conferences? Are teachers encouraged to attend computer conferences? Are study leaves given to educators who want to study the computer field? Who gets the curriculum planning and development money that gets spent each year? It is evident that a school system has many resources that might be brought to bear in the instructional computer area. This type of analysis suggests that a TC needs to know the ins and outs of educational politics and the overall budgeting and spending process.

The money resource is (will likely always be) very important. A TC will have a budget and may have to make a case for a still larger budget. A TC makes recommendations involving large amounts of money from general district funds. A TC may be responsible for drawing up specifications so that vendors can bid to provide hardware and software. This analysis suggests that budgetary and financial skills are useful.

Planning is done in light of a school or school district's overall goals and plans. This suggests that a TC must work with high level administrators, planners, and possibly with parent groups and the school board. Once again, this suggests the need for good skills in dealing with people. It also suggests the need for good written and oral communication skills and for a broad general knowledge of curriculum at all levels.

Some school districts analyze the overall duties of a TC primarily based upon the above (planning) ideas. This could lead to a conclusion that a TC is primarily an administrator and should hold an administrator's credential. (See the diagram given below. It suggests that the typical TC holds a position that overlaps with both the teacher and the administrator positions.) Certainly it leads to a conclusion that a school district TC should be paid on the administrative pay scale. It is clear that administrative skills and good ability to work with administrators are essential. But many of the implementation aspects of a TC's work require other types of knowledge and skill. Most people who hold administrator's credentials lack the computer-oriented technical knowledge and experience needed to be a good TC.



The overlapping job responsibilities of the TC.

Implementation

Implementation, of course, involves still more planning. But it also involves acquisition and maintenance of hardware, software, and supportive materials; teacher, administrator, and parent education; curriculum development and assistance to teachers; technical support to people at all levels; and facilitating change in the overall educational system.

One need only analyze any one of the five areas listed in the previous paragraph to see the difficulties in being a TC or the difficulties in specifying needed qualifications of a TC. Consider, for example, the acquisition and maintenance of hardware, software and supportive materials. As suggested in "The Two-Percent Solution" in Appendix C of this book, a school district can easily spend well over one percent of its overall budget in this area. In 1992 dollars in a district with 10,000 students that could amount to over a half million dollars per year.

Dealing with such funds is no small task. The process of going out for bids on computer hardware or software is quite complex. Contracting for the actual purchase of hardware and software involves careful negotiation with vendors. Such negotiations may take months; meanwhile, new equipment comes on the market and prices may change drastically. The legal aspects can be very difficult. A person carrying out these activities may need some school law and fiscal training.

Or, consider teacher, administrator, and parent education in a district of 10,000 students. The TC may be responsible for the computer-oriented education of over 500 educators and perhaps 10,000 parents. This responsibility could well be equivalent to a full time college-level teaching position. The typical TC has been a classroom teacher. However, the teaching of teachers, school administrators, and parents is quite a bit different than teaching children. It is a new set of skills to be mastered.

The issue of technical support to teachers and administrators is particularly difficult. If each school has a TC, quite a bit of the technical support can be done by this person. However, if individual schools do not have TCs with release time, then the district TC is apt to be inundated by requests for technical support. Note also that if a district does have TCs in the schools, than the district TC is apt to be called upon to be the technical support person for the school-level TCs.

A school district TC must also deal with large problems with considerable technical complexity. A common situation is that a school district already owns quite a large number of one or two different models of microcomputers. It needs more equipment. Should it buy more of the same, or should it be open to acquiring something different? A decision must take into consideration the current investment in both software and in teacher knowledge. It must consider how well current equipment is standing up under its use, and it should consider long term vendor support. Will the local vendor or the manufacturer still be in business a couple of years from now? Will a growing amount of educational software be available for the machines one is considering? Such questions make computer acquisition a hard issue.

Similar questions arise as a school district considers networking (Should our district install a fiber optic network?) and Integrated Learning Systems (Should our district install an ILS in each school?). Such decisions involve very large expenditures.

Change Agent

An TC is a change agent, dealing with a rapidly changing field and helping to facilitate change. The totality of computer science and computer education knowledge is expanding very rapidly. This suggests that a TC should be an intelligent, hard-working individual who is open to new ideas and comfortable with change. A TC must have a technical background that makes it possible to keep up with changes in educational computing.

It also suggests the value in having specific training in educational change processes. For example, Joyce and Showers (1988) have done extensive research on educational change and effective inservice projects. Inservice education can be vastly more effective in producing educational change if it incorporates what is now well known about how to design and conduct inservice education. For example, most inservice is done using the self-contained, one-shot approach. Research suggests that this is quite ineffective. Much more change occurs in the classroom behavior of teachers if inservice is backed up by follow-up activities such as additional sessions and classroom visits. Inservice instruction should include practicing the behaviors to be implemented in the classroom. Teachers can be taught to be coaches for each other. A support system of teachers all involved in a particular educational change is a considerable aid to realizing that educational change. Educational change is much more apt to occur if a school principal is actively involved in learning about and helping to implement the proposed changes.

The feedback mechanism for change is evaluation. Schools and school districts need to evaluate their instructional uses of computers to see if they are effective. Evaluation is an essential, and usually overlooked, TC responsibility. A step-by-step plan for evaluating the computer program of an elementary school is given in Mowe (1990).

Job Description for a District TC

The actual job description of a TC will, of course depend upon details of the particular position. Chapter 4 listed some possible responsibilities of a school-level TC. The following list is more appropriate to a district-level TC, but certainly overlaps the school-level TC list. Think of this as a shopping list. No district-level TC can be expected to do all of these things. But all of these things may be deemed desirable by a particular school district. If so, more than one person will need to be involved in carrying out these responsibilities.

1. **Leadership:** Take a leadership role in developing and implementing a district plan for instructional use of computers; the implementation should include provisions for evaluation and periodic updating (Moursund and Ricketts, 1988).

   This involves a large number of different tasks. For example, work with principals, department heads, school-level TCs, teachers, and others who will help implement the district plan. Develop a cadre of school-level TCs and computer teachers who are committed to implementing the district plan. The district TC should meet regularly with these school-level leaders. Each school should have a computer committee charged with developing and implementing a plan for instructional computing in their school. These school plans will vary from school to school, but should all be consistent with district plans. Make sure the school plans provide for procedures to assess progress in achieving the goals set in the plan. Establish evaluation guidelines so that data from different schools can be compared and can be used as part of the evaluation of district progress.

2. **Finances:** Understand the district budget, budgeting process, and spending process; work within this system to secure adequate resources for instructional computing. Provide budgetary leadership in the instructional computing field. Make effective use of one's own budget and staff. Help to ensure that school-level budgets and the district budget adequately support the district's instructional computer plan. Be especially aware of equity issues when doing budgeting and distributing resources.

3. **Resource center:** Develop a district computer resource center to be used by school-level TCs, computer teachers, computer-using teachers, and others. The resource center may contain hardware, software, courseware, and instructional support materials such as books, magazines, journals, films, and video tapes. When an especially nice piece of hardware or software comes out, obtain it for the resource center. Even a temporary loan, with an open house and publicity to the district personnel, can be quite helpful. A district computer resource center may be a lending library for both software and hardware that particular schools need only infrequently. It may be used as a meeting place for computer education committees and as a lab for computer inservices. Help to develop resource centers in every school. These resource centers may be an integral part of the facilities needed for inservice education. A school resource center should take into consideration the needs of teachers in the school.

4. **Resource people:** Develop and maintain a list of resource people. Some parts of this list may be suitable for distribution throughout the district. Other parts may be just for personal use. The list might include the entire district staff, with information about the computer background, interests, and involvement of each person. Identify at least one computer leader in each school and one computer-oriented leader in each academic discipline. Encourage each school to develop a list of parents who might volunteer their services as computer aides, technical assistants, or fund raisers. Develop contacts with vendors who are willing to provide loans of hardware and software; some vendors provide free training to educators.

5. **Inservice plan:** Develop, implement, and periodically evaluate a district computer-oriented inservice plan (Moursund, 1990b). One goal of this inservice plan should be to identify and/or help develop resource people in every discipline and at every grade level who can provide leadership in working to accomplish the district instructional computer plan. A second goal should be to help all teachers and school administrators become functionally computer literate and to learn their roles in accomplishing the district instructional computing plan. Ideally, every educator in the district should have a personal plan for becoming more computer literate. A district inservice plan needs to take into consideration workshops and courses

available from other school districts and from nearby colleges and universities. Private businesses may provide appropriate training on a contract basis; sometimes they will provide free workshops, perhaps to encourage possible purchase of a new product.

6. **Hardware and software acquisition:** Help the district to develop and implement plans for the acquisition and maintenance of hardware and software. Acquisition will likely involve going out for bids for both hardware and software about once a year, although one may be able to piggyback on a state or provincial purchasing contract. It is highly desirable to have all schools take advantage of the prices obtained through these bid processes. Thus, the school district acquisition plan should be followed by the individual schools and the school district. However, the overall acquisition process must be flexible. Schools and individual teachers may have needs that cannot easily be met working through a district acquisition plan. For example, a special education teacher may need an input device controlled by eyebrow movements. A magnet arts school may need special graphics equipment or music synthesizers. Such special needs should be met in a timely fashion.

   Maintenance will include routine preventative maintenance as well as more general repair and replacement. It might prove desirable to have one teacher in every school trained to do a minimal level of maintenance. In secondary schools one might want to have some students trained to provide this service. A district may want to maintain a supply of spare parts and hire a person who can repair the types of equipment the district is acquiring.

   The district software policy should also address the issue of whether the district or individual schools will support, encourage, or discourage software development. It should contain a clear statement against software piracy. District inservice programs should address the software piracy issue; the goal is to have the district policy understood and supported by all school personnel.

7. **Hardware and software inventory:** Maintain an accurate inventory of computer hardware and software that belongs to the district and to individual schools in the district. Help set policy on the possible creation of a district-owned pool of hardware and/or software that resides in particular school buildings and that can be moved from school to school as needed. Help establish procedures for schools to borrow software from each other. Work to establish an "effective life" for hardware and software, so that hardware and software that is no longer appropriate to use can be removed from service.

8. **Research and evaluation:** Help develop and implement a district procedure for the evaluation of software, hardware, and courseware, and for the sharing of the results of such evaluation. Be involved in district research projects to evaluate instructional use of computers. Tie in with other school districts and with national organizations that are doing software evaluation. Acquire books and periodicals that evaluate software.

   Design and encourage pilot (research) projects. For each new "innovation," eventually your district must decide whether to adopt and implement its use. Pilot studies can help answer such questions.

9. **Information dissemination:** Disseminate computer-related information throughout the district via a newsletter, computer bulletin board, presentations at district and school staff meetings, and so on. Establish a liaison committee of key people in the community and meet periodically with this committee. Help to create and/or work with a local computer-using educators group. Work with a state or provincial group of computer-using educators. Be an active participant in local and regional non-

computer education conferences, perhaps doing presentations on computer applications.

10. **Community relations:** Work on community relations by speaking to parent and professional groups, publicizing the district computer plan and progress. If possible, arrange for newspaper, radio, and television publicity. Consider having the district or individual schools participate in computer-oriented science fairs and in computer programming contests. Encourage schools to have computer-oriented open houses for parents, with students demonstrating what they have learned about computers. A school computer club might want to raise money by using school computer equipment to instruct parents in how to use computers.
11. **Hiring policy:** Encourage the development and implementation of a district hiring policy that takes into consideration the computer knowledge and experience of applicants, and gives preference to computer literate applicants. Communicate to teacher training institutions that your school district is only interested in hiring computer literate teachers.
12. **Fund raising:** Help the district to obtain outside funding by participating in grant planning and proposal writing. Try to find funds to support individual teachers in developing pilot studies on various instructional applications of computers. Help individual teachers obtain funding to go to computer-in-education conferences and to participate in staff development.
13. **Improve education:** Work to improve the overall quality of education received by students in the district. Be sensitive to equity issues and work to resolve inequities. Be an educational change agent. Be aware of technology trends and possible futures of the field of computers in education. (This is discussed more in Chapter 10.)
14. **Technical competence:** Remain technically competent. Continue to grow as a professional computer educator, as an educational leader, and as a human being. Be professionally active (attend meetings, give talks, write articles) at a regional or higher level. Subscribe to computer-oriented educational publications and schedule regular time to read them. Be aware that the computer field is changing rapidly. A TC who doesn't spend substantial time acquiring new knowledge and skills will eventually be technically incompetent.

Concluding Remarks

Technology is a very powerful force for change. One of the central theses of this book is that the TC is a change agent—a leader in school restructuring to help move our schools into the Information Age.

This chapter and previous chapters contain lists of possible duties for a school-level or a school district-level TC. When taken all together, such lists are overwhelming and should be used with some care. They can assist a school district or TC in writing a job description. But this requires careful thought, to match the responsibilities to particular needs of the district and/or to particular qualifications of the TC. The next chapter discusses possible qualifications of a TC.

Chapter 8

General Qualifications to be a Technology Coordinator

Chapter 4 contains a list of possible responsibilities of a school-level TC and Chapter 7 contains an extensive list of possible responsibilities of a district-level TC. These lists give an indication of the types of activities a TC may be called upon to perform. From these lists one can determine the types of qualifications a TC might need. In this chapter we categorize and discuss these general types of qualifications.

Four Categories of Knowledge and Skills

At first glance it could seem that the variety of knowledge and skills a TC might need is beyond that of an ordinary mortal. A frequent statement of teachers who are thinking about becoming TCs, perhaps only partially facetious, is, "If I had all of those qualifications, I'd leave education and get rich." And yet, many people satisfy the requirements and do remain in education. Being a TC is a challenging, but rewarding career. It is a career offering the opportunity to make a significant contribution to education and to experience substantial personal growth.

The general qualifications to be a TC can be divided into four main categories. The categorization is somewhat arbitrary and some categories overlap; still, this categorization approach is useful. Notice that the first three categories do not address technology, computers, or related underlying theory of this field.

1. A broad general education and dedication to lifelong learning. Overall intelligence and perseverance; a strong work ethic; high ethical standards; self confidence; good time-management skills; budgeting and other fiscal skills.
2. Knowledge of and support for our educational system; good skills in teaching school children as well as in teaching educators and other adults. Knowledge of curriculum, curriculum development, and school reform. Knowledge of testing and assessment.
3. Interpersonal relations skills, especially in being a good listener; skills in written and oral communications; administrative skills. Good telephone and electronic mail communication skills.
4. Technical knowledge in the fields of computer science, computer education, and the broad range of technologies used in hypermedia environments. Knowledge of the theory and practice of instructional technology. Substantial experience in working with students and educators in the instructional technology field. Knowledge of teaching and learning theory as they relate to roles of computer-related technology in content and pedagogy.

The responsibilities placed on a TC vary widely from district to district and from school to school. Thus, it is not possible to specify an ideal mix of strengths from the four-part list given above. Each area is important.

The first general area of qualifications is based upon the need for a TC to work with a diverse group of educators and students. At one moment a TC may be responding to the needs of an art teacher; next may come a problem from a mathematics, social studies, science, or industrial arts teacher. Later a school board member, a superintendent, or a principal may raise specific issues; a budget officer may raise questions about budgeting for the purchase of hardware and software. The TC must be able to meet all such people at least somewhat on their own grounds.

TCs spend most of their time interacting with people. Each person coming to the TC has specific problems and is seeking help. Since the total number of people with problems is large, the demands placed upon a TC's time are also large. Time management skills are quite useful. It is common for TCs to work 50-60 hours or more per week, and still feel that there is not enough time to do what needs to be done. (See the INTERVIEWS section of this book.)

One of the big demands upon a TC's time is keeping up with changes in the computer field. It is helpful to be a rapid and voracious reader. Overall intelligence and a broad educational background are quite helpful in keeping up.

A TC is an educator, working in a school setting. The TC has as a major goal working to improve education through appropriate uses of computers. The second general area of qualifications suggests that a TC should be an experienced teacher, preferably with teaching experience at a variety of grade levels. The TC should have experience in working with children and computers. The TC should feel comfortable in going into a classroom and presenting computer-related ideas to students at all levels. Moreover, most TCs have substantial adult education responsibilities. Teaching teachers and teaching school administrators are quite demanding tasks. A person can be quite successful at teaching younger students and fail miserably in teaching adults (or vice versa).

The third general qualification area includes all aspects of communication with others in one-on-one and small group setting. TCs spend most of their time working with people, and being a good listener may well be the single most important qualification to be a successful TC. TCs must be skilled at sensing the feelings and moods of individuals and groups. They must be skilled in working with people to accomplish specific tasks. TCs spend a great deal of time in meetings with school administrators and teachers. Often it is necessary to prepare written materials for use in these meetings as well as written reports of the meetings. A TC with poor writing skills is severely handicapped.

The fourth qualification area concerns specific technical qualifications in computer science, computer education, and the full range of topics in the field of instructional systems technology. In essence, the first three types of qualifications are important to any person working as a curriculum coordinator or instructional leader. It is this fourth area that allows a person who meets qualifications 1-3 to function well in the instructional systems technology field. Chapter 9 discusses this topic in more detail.

Which Are Most Important?

It is unlikely that a person seeking a TC position will be equally qualified in all four areas. More typically, a TC is reasonably well qualified in all four areas but is particularly strong in one or two of the areas. In a number of workshops for computer leaders, I have asked participants to rank the four qualification areas in order of importance. Invariably the interpersonal skills area is ranked as most important while the technical skills area is ranked least important. My personal opinion is that these two areas should be tied as most important.

The typical person who would like to be a TC is currently an experienced, successful, and hard-working school teacher. This suggests that the person is likely to meet whatever minimal requirements might be set for qualification categories 1. and 2. above. Of course, additional training and experience may be required. For example, many teachers lack administrative training and experience. Their knowledge of school budgeting processes and dealing with budgets may be weak. Their knowledge of school curriculum and change processes in education may be limited to the grade levels and subjects they teach.

Qualification category 3 concerns interpersonal and communication skills. The majority of current TCs rate this area as the most important from the total list. A person who has weak interpersonal and communication skills is not apt to succeed as a TC. In particular, a person who is a computer hacker, who prefers to be with computers rather than with people, may well prove to be a very poor TC. Fortunately, interpersonal skills can be improved by training and experience.

A surprising number of people who seek TC positions have poor writing skills and are uncomfortable when communicating in writing. This seems to be particularly true for teachers who were initially prepared to teach mathematics and/or science. They tend to have had less practice in writing than many other teachers. Writing skills can be improved by study and practice.

The final issue is how much technical knowledge in computer science, computer education, and instructional systems technology is required. It is said that in the world of the blind, the one-eyed person is monarch. Few school teachers have a substantial knowledge of computer science. Many people who currently hold TC positions have only a modest level of computer-oriented technical knowledge. Probably less than one percent of such people have computer science knowledge equivalent to that a student obtains in a bachelor's degree in computer science at a good university or in a good master's degree program in computer science education. This may be contrasted with the academic preparation of subject matter coordinators and specialists in other disciplines. There, a subject-specific bachelor's degree and an education-oriented master's degree are commonplace.

The issue of needed levels of technical knowledge is confused by the possible breadth of responsibilities of a TC. In the learning/teaching about computers area, it is desirable that a district have considerable technical expertise. In a small district much of this expertise might be provided by a TC. In a large district it is more apt to be provided by the computer teachers.

Similarly, learning/teaching using computers can require considerable technical expertise, both in the computer field and in the areas of teaching and learning theory. In a small district the TC may be the prime source of this expertise. In a large district help is available from curriculum coordinators, evaluation specialists, and a variety of teachers.

My personal opinion is that a lack of technical knowledge is a major handicap, both to the TCs and to the school districts in which they work. It is a handicap that a TC can partially overcome by added strengths in the other three areas. But good long term progress of the field of instructional use of computers at the precollege level requires that its leaders be technically competent. The next chapter discusses this topic in more detail.

Concluding Remarks

This brief chapter contains a list of four major types of qualifications that relate to being a successful TC at the school or school district level. Three of the major qualification categories are independent of specific technical knowledge, while the fourth focuses on technical knowledge and skills.

A person seeking to become a TC can examine the lists of possible job responsibilities given in Chapters 4 and 7. The person can do a self-assessment against the types of qualifications discussed in this chapter. The results should provide guidance for deciding whether to pursue such a career and/or for negotiating specific job responsibilities. It should also help one determine a plan for self-improvement.

Chapter 9

Technical Qualifications to be a Technology Coordinator

A TC must work with a wide range of people such as teachers and students, school administrators and parents, and computer vendors and computer scientists. The TC must keep up with progress in computer-related instructional materials, hardware, software, applications, and the discipline of computer and information science as it relates to precollege education. The recent very rapid growth of hypermedia in education has further broadened the range of technical knowledge needed by a TC.

It is clear that the job of being a TC is technically very demanding. This chapter explores possible technical qualifications to be a TC. It does this mainly through listing components in a relatively strong computers in education master's degree program.

Needed Levels of Computer Technology Knowledge

Previous chapters in this book have indicated that the job responsibilities of different TCs may differ substantially. Thus, it is evident that there will not be uniform agreement on the technical knowledge and skills needed to be a TC. The knowledge and skills will vary widely with the nature of the job.

A major aspect to consider when analyzing needed technical knowledge and skills is the nature of technical support available to the TC. In a small school district there may be no teachers or other staff who have a good knowledge of computer technology and computer science. Then the TC must be the technical expert as well as handle a variety of other duties. In a larger district there may well be a number of teachers with substantial computer science knowledge. A TC may well have staff with substantial technical knowledge. Strength in interpersonal skills may well be most important to a TC of such a district.

Needed technical knowledge and skills may differ significantly between an elementary school and a secondary school TC. The amount of computer science that is integrated into the elementary school curriculum may be modest compared to what might be integrated into the secondary school curriculum. The elementary school TC may be mainly a computer-assisted learning specialist or perhaps a computer-integrated instruction specialist. This type of analysis suggests that an elementary school TC may not need to know as much computer science as a TC at a secondary school or district level. Of course, at both of these school levels, the TC may need to be in charge of a rather complex computer network system.

There is still another major factor that must be included in this analysis. Over the short run, TCs are having to make major decisions about all aspects of instructional use of computers. National and state goals have not been set or carefully defined. Standardized hardware, software, curriculum guides, and support materials do not exist. Computer use has not yet been integrated into the widely adopted textbook series. There are relatively few computer-literate teachers, and most people just entering the teaching profession are computer illiterate. In other words, the whole field of instructional use of computers is still in its infancy; this places additional burdens on TCs.

Graduate Studies in Computers-in-Education

The problem of how to train TCs and computer teachers has existed for many years. The Illinois Institute of Technology (in 1969) and the University of Oregon (in 1970) were pioneers in analyzing and responding to this need. These schools started the first master's degree programs in computer education. In the early 1980s there was a proliferation of certificate programs and master's degree programs in computer education. Now some of these programs use the more modern title of Instructional Systems Technology, which is gradually replacing the title Computers in Education.

A certificate program often has about one-third to one-half the technical content of a master's degree program in computer education. Both master's degree and certificate programs are designed to prepare TCs and computer teachers. The typical program is apt to include students with both career goals in mind.

Details and specific requirements of master's degree programs vary from school to school. However, a master's degree usually requires a minimum of 30 semester hours (45 quarter hours) of graduate credits. Often such programs require slightly more than this minimum number of hours. A master's degree program in computer education may have various prerequisites for admission and a variety of major components. The program described in this section is a composite drawn from a number of universities. If you are looking for a program of study, the program given here provides some hints of what to look for and perhaps a basis of comparison. If you feel you have acquired the equivalent of a master's degree through the school of "hard knocks," the program of study listed here gives you a basis for analyzing your self education.

Entrance Requirements

The entrance requirements for admission to a master's degree in the field of computers in education vary considerably from school to school. Generally, the requirements are the same as for admission to any college of education master's degree program plus some background in the computer field. Thus, the applicant must have relatively decent undergraduate grades and be an experienced teacher.

The required computer background falls into two categories: programming and applications. In the early 1980s it was generally assumed that the applicant knew at least one programming language quite well and had a substantial interest in computer programming. Often an applicant had only a little experience with applications such as a word processor. This has gradually changed. Now, it is common for an applicant to be quite proficient in use of a wide range of computer applications, but have little or no programming background. The applicant may say, "I know a little Logo." or, "I know a little BASIC." A probe into this knowledge suggests the applicant has had a short course or is self taught, and does not have a working knowledge of programming. On the other hand, the applicant may be proficient in use of a very sophisticated desktop publishing package or in an integrated applications package.

Nowadays the typical applicant has had considerable experience in using computers with students. The typical applicant is a teacher who owns a computer and is likely serving the role of school-level TC. The applicant has worked with one or two different microcomputers and has had several years of computer experience. The applicant has little appreciation for or knowledge of the history of the field of computers in education. A question such as, "Have you heard of Robert Taylor and his book on Tutor, Tool, Tutee?" is generally met with the response, "No." This book contains seminal articles written by five of the pioneers in the field of computers in education (Taylor, 1980).

Over the long run, prerequisites for admission to a master's degree program or a certificate program will gradually increase. These programs will eventually be fed by a stream of students who first encountered computers while in elementary school, and who have had many years of computer experience. Already we are beginning to get students into these programs who have used computers throughout their undergraduate college work. It is now becoming common to assume that applicants have had a course on Fundamentals of Computers in Education such as is being widely required for teacher certification.

Special mention needs to be made of the situation where an educator wants to become prepared to be a secondary school computer science teacher. Several states in the United States have certification requirements for this position. Requirements usually include a substantial core of computer science coursework. This type of coursework is most often offered by a department of computer science. Most master's degree programs in the field of computers in education do not offer enough "straight" computer science to adequately prepare their students to teach the full range of computer science and computer programming courses that a high school might offer.

Introduction to Computer and Information Science

(6 semester hours = 9 quarter hours)

This is a year sequence designed to introduce educators to the field of computer and information science. It includes a substantial introduction to programming in at least two languages, perhaps Pascal and either Logo or BASIC. There is a growing trend to use the underlying language from HyperCard or LinkWay as one of the programming languages.

These programming courses stress problem solving, top-down analysis, control structures, data structures, machine architecture, and general theory of computer science. They include some introduction to operating systems and to computer hardware. There should be a solid component on building and maintaining a computer network and dealing with a wide range of telecommunications facilities.

The focus on computer programming should have a strong emphasis on program design, problem solving, program testing and debugging, and modern theories of the modular design of programs. Students should be expected to write high quality, well designed, well documented, well tested programs with good quality user interfaces. The goal is *not* to make the students into professional computer programmers. However, the goal is to develop a solid appreciation for the level of knowledge and skills required to be a professional programmer.

The amount of computer science and computer programming covered in this course is substantially less than that covered in the high school Advanced Placement (AP) course. Some educators in the computers-in-education master's degree program want to become prepared to teach the AP course. Adequate preparation for this course includes a minimum of the first two year sequences for computer science majors, plus some discrete mathematics and some computer science teaching methods. Relatively few computer-in-education master's degree students are currently taking this type of program of study.

Master's degree programs attempting to prepare teachers to teach the full range of high school computer science and computer programming courses encounter the difficulty that often the needed coursework is offered by a computer science department and carries a lower division course number. This means that the courses do not carry graduate credit. This may mean participants in such a program of study must take an extra year of coursework in order to complete the degree.

Computer Applications

(6 semester hours = 9 quarter hours)

This may be organized as a year sequence or as a collection of self contained courses. It covers computer-integrated instruction (CII)—uses of computer-as-tool. Generally the sequence assumes initial familiarity with word processor, database, and graphics software, such as in an integrated package. The stronger programs no longer give credit toward the master's degree for an introductory course in *AppleWorks* or *Microsoft Works*.

This year-long sequence has a hands-on, very practical orientation. Students work with a wide range of software, do a lot of software evaluation, develop lesson plans, and explore curriculum changes that accompany increased tool use of computers. The course may center around hypermedia, with students doing substantial hypermedia projects. Substantial use of telecommunications should be integrated into the course.

The application courses should have a strong instructional technology (instructional design working with a full range of multimedia) component. Participants should become proficient in designing materials for desktop presentation and for desktop publication that use the full range of multimedia.

The sequence should use problem solving as a unifying theme. The book by Moursund (1990a) includes a good overview of the topics that should be covered. There should be substantial emphasis on transfer of learning and on learning to learn.

This sequence should also include an introduction to computer-assisted learning (CAL). This should be at a familiarization level, rather than at a level designed to produce CAL developers. A student wanting to specialize in the development of CAL materials will likely require much more than a master's degree level of preparation. Such work is apt to require substantial knowledge of curriculum design, curriculum development, learning theory, teaching theory, computer programming in a language such as C, visual perception, and other topics not adequately covered in the master's degree program being discussed here.

Participants in this year-long sequence will likely have a wide range of academic disciplinary interests. Thus, some will want to study computers in math, while others will want to focus on computers in music or on computers in the language arts. If the sequence is offered as a collection of discrete courses, there may be courses on these topics and on others, such as computers in science and computers in art. In any case, there will be a substantial underlying theory of curriculum design and curriculum development. There will be a focus on school improvement and change.

Computer Education Leadership

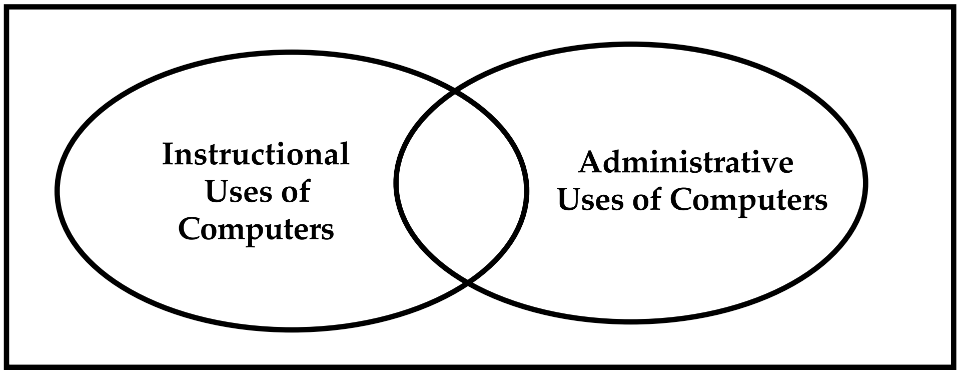
(6 semester hours = 9 quarter hours)

The master's degree program is designed to produce TCs who will play a leadership role at the school or district level. A year-long sequence or a year of self-contained courses focus on leadership, staff development, long-range planning, and the frontiers of the field of computers in education. The book you are currently reading could be used in the first part of this year sequence. The books by Moursund and Ricketts (1988) and Moursund (1990b) help define the material to be covered.

This sequence should have a major focus on current literature. Participants should get used to reading a wide range of periodicals and they should develop methods that will help them to keep up in the field as they work as TCs. They should become quite familiar with the megatrends in the field of computers in education. They should explore topics such as distance education and integrated learning systems.

This year-long sequence should also have a substantial hands-on component. However, in this case the hands-on component is actually designing and doing inservices, and actually doing long-range planning for computers in a school or school district.

Finally, this sequence provides some introduction to administrative uses of computers. The goal is to help participants understand that there is a substantial difference between instructional uses and administrative uses, but that these two areas are gradually growing closer together.



Instructional and administrative uses of computers.

General Education

(6 semester hours = 9 quarter hours)

Most master's degree programs require at least the equivalent of a one-year sequence in graduate courses in education that lie outside of the field of computers in education. These might have titles such as Research Methods in Education, Master's Seminar, Modern Education Problems, Curriculum Development, Instructional Design, Modern Foundations of Education, and so on. Generally the goal is to assure breadth and some mixing of students from the different master's degree programs.

Master's Project and Specialization

(6 semester hours = 9 quarter hours)

In a typical program of study there is the equivalent of a one year sequence of coursework devoted to electives, specialization, and a major project. This allows the student to gain a greater level of in-depth knowledge of a particular field.

In some degree programs this year sequence is used to take additional coursework in the field of computer science. If the student begins with a reasonably strong computer programming background, this additional coursework should prepare the student to teach the full range of computer science and computer programming courses in a high school.

In other degree programs this additional coursework might be in instructional technology. The focus might be on product development in a multimedia environment.

In still other degree programs, this additional coursework might focus on adult education or on courses needed to obtain an administrative certificate.

A master's project often represents about 100 to 200 hours of work, or more. A good project has the characteristics:

1. The project is built on a number of the ideas and general knowledge covered in the master's degree program. The project should not be one that the educator could have easily undertaken before entering the degree program.

2. The project is of substantial interest to the educator. For example, the project may be the design and use of a unit of instruction that fits well into the educator job situation.
3. The project is of value to others; it should be a significant contribution to the field of computers in education. A particular audience (teachers, administrators, educational decision makers, precollege students, etc.) should be identified. The project should be designed to be useful to that audience.
4. The project should be of high quality. It should be well written, technically correct, and interesting.

Concluding Remarks

It should be evident that the combined fields of computer science and computer education is very large. A certificate program may cover about one-third to one-half of the requirements of a strong master's degree program. A carefully designed master's degree program can include adequate formal education to be a computer teacher, a specialist in computers in a specific discipline, a school-level TC, or a district-level TC. A certificate program will, necessarily, have more limited goals. However, it can certainly prepare an educator to be a school TC.

Eventually, the largest school districts may want their TCs to have still more formal education, such as a doctorate in computer education. The TC may be an Assistant Superintendent for Technology. Currently there are relatively few people with such credentials. People earning a doctorate in computer education are generally taking positions in higher education or in the private sector.

It is often said that it takes 50 years for a major change to occur in our educational system. We can understand why this is so by studying how our educational system is coping with the field of computers in education. Currently there are a large number of precollege students who know a great deal more about computers than do their teachers. More and more students are receiving a substantial introduction to computer applications while in elementary or middle school. More and more students are routinely using computers while they are in high school and college. Eventually, a number of these students will become teachers. They will, on average, know more about computers than will their students. They will be able to contribute substantially to a rising tide of computer knowledge and skills that are woven into the fabric of the curriculum, However, this takes a long time to accomplish.

It is evident that the rising tide of computer knowledge and skills on the part of students and the general teaching profession is a challenge to TCs. They need to be at the forefront, providing leadership. They need to help design the new curriculum. They need to help do the long-range planning. They need to be a solid source of information and of help to students and teachers who are struggling to learn more about the field of computers in education.

Chapter 10

The Future of Computers in Education

Author's Note: This chapter is adapted and updated from a chapter by the same title that was published in Moursund and Rickets (1988). The reader is strongly encouraged to first read Appendix B: Historical Look at the Future, before reading this chapter. That Appendix is a chapter from the predecessor of this TC book, published in February 1985. It is indicative that we can do a relatively good job of predicting a number of key ideas within the computer education field about five years into the future.

Introduction

The first general-purpose electronic digital computer built in the United States became operational in December 1945. A special purpose electronic digital computer used in breaking codes was developed and extensively used in England several years earlier, while major progress in developing a general purpose computer occurred in Germany still earlier.

Initially many people felt that the total worldwide demand for electronic digital computers might be a dozen or so. However, computers became commercially available in the early 1950s and the market has expanded rapidly since then. This rapid expansion has been fueled by continued hardware and software improvements, rapid price-to-performance decreases, and a broadening perspective of possible uses of a "mind tool."

Today's microcomputers outperform mainframe computers from 15-20 years ago, and we'll likely be able to make a similar statement 15-20 years from now. Technological progress continues unabated. At an August 13-16, 1990 meeting of the Christopher Columbus Consortium, a project funded by Apple Corporation, Jean-Luc Lebrun reported:

1. The amount of internal memory in new microcomputers is increasing by a factor of four every three years.
2. The amount of mass storage in new microcomputers is increasing by a factor of two every three years.
3. The CPU speed of new microcomputers is increasing 70% per year.

Jean-Luc Lebrun is with the Advanced Technology Group at Apple. He indicated that it is likely that this rate of change will continue at least until the year 2000. This means that a top-of-the-line microcomputer of the year 2000 would be roughly equivalent to the $10 million top-of-the-line mainframe computer of 1980.

So far, the educational impact of computers has been modest. However, we are now in a period of relatively rapid growth of computer availability in schools. We can now see some of the changes that computers may bring to education. It seems clear that eventually computers will be an everyday tool of students at all grade levels and throughout the curriculum. Both the content and the pedagogy of education will be profoundly affected.

This chapter is divided into a number of sections. First comes a general discussion of the basis for our predictions. The astute reader will notice that this chapter is not a summary of the literature (notice the lack of a bibliographic references in this chapter). However, there is considerable underlying logic and evidence to support the predictions. Most of the predictions are statements about current trends and are not quantitative in nature.

Next the chapter discusses some trends in hardware, software, networking, computer science, and overall applications of computers in instruction.

The chapter concludes with several recommendations. These recommendations are based on the overall prediction that computers will lead to profound changes in our educational system.

S-Shaped Growth Curve

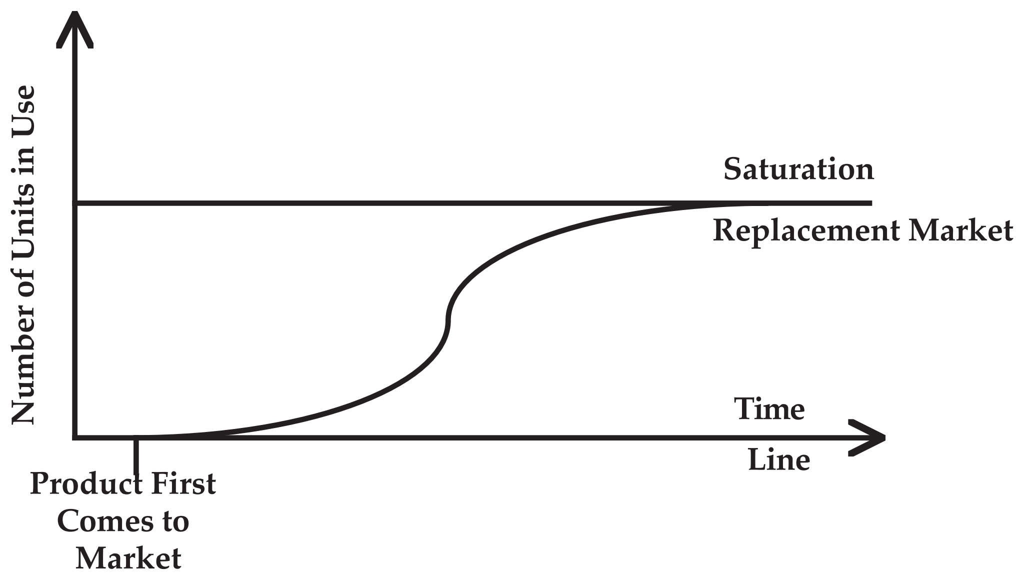
General-purpose computers for use in instruction and research began to come into colleges and universities in the middle to late 1950s. The IBM 650, a first-generation (vacuum tube) machine, was typical of the commercially available computers in those days. If two ten-digit integers had been placed in the right registers, it could add them in a thousandth of a second! When suitably programmed to calculate a square root of a ten-digit integer, it extracted the square root in an eighth of a second. Needless to say, students studying this machine were quite impressed by its "blinding speed." Such a machine served the entire research and instructional needs of major research universities such as the University of Wisconsin, Madison.

Now, of course, millions of people own personal microcomputers with far more compute power than an IBM 650. Indeed, some handheld calculator-computers have greater speed and more memory than the IBM 650. A handheld, solar battery powered calculator costing under $5 can calculate a square root in about a quarter of a second.

Historically, as soon as computers came into colleges and universities, people began to experiment with their use in high schools. Some high school students learned to write computer programs during the late 1950s. However, widespread school use of computers had to wait for decreased prices and increased availability of the hardware.

Computers are an example of technology, and many other technologies have come into our society. For example, the telephone was invented by Alexander Graham Bell in 1876. But initially there were no telephone lines, central switching stations, or people trained in making effective use of telephones. Now, more than a century later, the telephone market is still continuing to expand.

After its invention, a technologically based product must undergo the work needed to produce a marketable product and then be brought to market. Under free market conditions, product acceptance and distribution is characterized by an "S-shaped" growth curve.



S-Shaped Growth Curve

Initial growth in use and acceptance of a new product is slow because the product isn't known to many people, the product is in short supply and may be quite expensive, the necessary infrastructure isn't in place, etc. When television was first invented there were no television stations, sales outlets, or repair shops.

Notice the period of rapid growth in the middle of the S-shaped growth curve. Both the number of years of rapid growth and the rate of rapid growth vary with the product. But eventually the market becomes saturated.

The instructional use of computers in education seems to be following an S-shaped growth curve. In precollege education we seem to now be in the period of most rapid growth. An educated guess is that the number of computers in precollege education in the United States reached 3.5 to 4.0 million in the fall of 1992. This is a ratio of about one computer per 12 to 13 students. This is, of course, a small number relative to the total number of computers being installed in businesses and households. Sales of microcomputers in the U.S. now exceed 20 million per year.

However, the reader should be aware that computers in schools may not continue to follow the S-shaped growth curve model. The education market isn't like the general consumer-based market. Funding for education is very tight, so computers-in-education may not follow a standard free market growth pattern. Indeed, in most school systems the majority of computer hardware has been purchased using non recurring funds, such as from various federal entitlement programs. Large cuts in these programs are possible, and there are other pressing demands on these funds.

Four Eras

A number of writers have examined and characterized major trends in human societies. They have identified four major ages: Hunter-Gatherer, Agricultural, Industrial, and Information. Until about 10,000 years ago, all societies were Hunter-Gatherer in nature. Then the Agriculture Age emerged in various parts of the world. Somewhat over two hundred years ago, the Agricultural Age began to give way to the Industrial Age in some parts of the world. (In 1776, at the time the American Revolution began, 90% of

Americans lived and worked on farms.) Finally, the Information Age began to emerge about 35 years ago in some industrialized societies. In the United States, the official advent of the Information Age is often listed as 1956 (Naisbitt, 1982).

The label "Information Age" is misleading. What has happened in the United States since the end of World War II has been a massive shift from a manufacturing economy into a service economy. For example, the number of fast food stores has grown very rapidly, as has the number of clerks working in these stores. These are certainly not high-tech, information-oriented jobs. Most of the service jobs pay far less than manufacturing jobs.

But information-related technology is certainly an important part of our Information Age. Who can help but be aware of the rapid growth of IBM, whose annual sales are in excess of 60 billion dollars? The rapid growth of Apple Computer Company and Microsoft has been spectacular. And computer-related technology has transformed many industries. For example, our telephone system is much better than it was when we were children, due to computerized switching, microwave transmission systems, satellites, fiber optics and so on.

Computers and computer-related technology are playing two ever-increasing roles in our Information Age. First, computers are a productivity aid in many situations. These situations range from a writer using a word processor to a librarian searching computerized data banks to a computerized robot helping to assemble automobiles. Second, computers are being built into many devices such as automobiles, microwave ovens, and television sets. Sometimes computer technology makes possible entirely new devices like electronic digital wrist watches and handheld electronic calculators. These two general categories of computer use—productivity and products—are now well established and will surely continue. They serve as a solid foundation for predictions about the future of computers in education.

Computer Hardware Trends

To a large extent the computer field has been driven by hardware progress, and this progress is showing no signs of slowing. We'll examine these trends and make a couple of general predictions. You should notice that these predictions are made quite independently of whether computers become of increased importance in education. That is, the education market isn't yet large enough to be a major driving force in the development of hardware. We have estimated that as of fall 1992, about 3.5 to 4.0 million microcomputers were used for instructional purposes in precollege education in the U.S. If all of this equipment had been purchased at that time, the entire cost would have been less than 10 percent of IBM's sales for 1992.

The ENIAC computer, which became operational late in 1945, was the first general-purpose electronic digital computer produced in the United States. It contained 18,000 vacuum tubes, and these vacuum tubes were at the very heart of the computational circuitry. The more special purpose electronic digital computers used in England during World War II contained about 1,500 vacuum tubes.

The transistor was invented in 1947; one can think of a transistor as being roughly equivalent to a vacuum tube. It took about 10 years before transistorized computers began to become available. At that time, transistors cost about the same as vacuum tubes, but used less power and were more reliable. Thus, they were a significant breakthrough in electronic technology.

In much less than another 10 years, the integrated circuit was in mass production. The IBM 360 series of computers that came out in the mid-1960s made use of integrated circuitry and were called third-generation machines. A historical note seems appropriate. When Dave Moursund (the author of this book) began teaching at the University of

Oregon in the fall of 1967, an IBM 360 model 50 mainframe computer had just been installed. The University of Oregon was quite proud of this new machine with its high speed 32-bit CPU, 256K-byte memory, multiple tape drives, and two five-megabyte hard disk drives. Later, at a cost of about a quarter million dollars, eight 27-megabyte disk drives were added to the system. The total system cost nearly a million 1967 dollars, not counting the air conditioned building that was constructed to house it and its staff.

In terms of CPU capability, primary storage and secondary storage, the cost of computers has come down by a factor of perhaps 1,000 during the past 25 years. Many people now own personal microcomputers with more primary storage and raw compute power than the IBM 360 model 50. These microcomputers are relatively portable; they need not be housed in a special, air conditioned computing center. There has also been substantial progress in software, a fact discussed later in this chapter.

The trend of packing more and more circuitry into a small chip has continued unabated. In 1990 several different research labs reported they were making significant progress in learning how to manufacture a 64-megabit memory chip. The predictions were that such chips would become commercially available by 1995. In 1992 several companies indicated that they believed they would be producing the 256-megabit chip by 1997.

The hardware progress has led to single chip 32-bit CPUs in 1981, second-generation single chip 32-bit CPUs in 1985, and a variety of still faster 32-bit CPUs since then. The Intel 80386 and the Motorola 68020 32-bit CPU chips introduced in 1986 rival the CPUs of medium-priced mainframe computers being produced at the same time. Since then, the much faster Motorola 68040 and the Intel 80486 have come into general use. For comparison purposes, think of the Motorola 68040 and the Intel 80486 CPU chips as being at least 50 times as powerful as the CPU in the IBM 360 machine from the mid 1960s.) Still greater compute power is available in the RISC (reduced instruction set computer) CPU chips that are now being used in many computer work stations.

Considerable progress in commercially available parallel processors, involving the interconnection of multiple CPUs and primary memory, has occurred in the past half dozen years. There are many problems where it is possible to write programs that take advantage of having a large number of CPUs. One such computer, called the Connection Machine, has 64,000 CPUs. Parallel processing is a rapidly growing field of research and implementation. In 1992 the company manufacturing the Connection Machine announced a new model that they believe will be able to carry out a trillion floating point computations per second. This is about a million times the speed of the "lightening fast" IBM 650 of the mid 1950s!

There is a strong trend toward building computers with very large memories. In 1986 several companies announced plans to build mainframe computers with a billion bytes of primary storage. Such machines will be particularly effective in solving certain types of problems that involve a large amount of data. Weather forecasting is an example. The microcomputer has not been left out of this rapid growth in primary memory. It 1990 it became possible to upgrade a Macintosh II microcomputer to 32 megabytes for about $3,000.

Computer hardware has made so much progress that it is now possible to design special circuitry and build special-purpose computers for a particular application. At Carnegie-Mellon University, for example, a special-purpose chess playing computer has been designed and built. This machine employs 64 special-purpose processors (one for each square on a chess board) in addition to a general-purpose processor that runs the master program and coordinates the overall efforts. The system can examine 175,000 possible chess moves per second. It recently won the North American computer chess title. Only a few hundred humans in the entire world play chess better than this computer.

The trend toward greater packing density in computer circuitry has made possible better and better laptop and palmtop (easily portable) microcomputers. Laptop microcomputers are now readily available, ranging in capability from not much more than a sophisticated pocket calculator up to machines fully as powerful as medium-priced microcomputer systems. Generally these weigh about five to 10 pounds. However, in the late 1980s several companies began to market "palmtop" microcomputers weighing about a pound. It is obvious that there will be a continuing trend toward better and better laptop and palmtop microcomputers.

Display screens and batteries remain major problems for portable microcomputers. Slow progress is occurring with display screens. Circuitry using less power is being developed, and batteries are very slowly being improved. It seems clear that the cost of portable microcomputers will slowly decline, as their compute power gradually increases. The market for medium-capability portable microcomputers is still modest in size, and prices are declining only slowly. One standardly sees such machines being used on airplane flights, but their use in classrooms is still rather rare. It seems likely that this use will increase steadily over the next 10 years.

Special mention should be made of neural net computers. This type of computer design interconnects a large number of processing units, somewhat in the same manner as neurons are interconnected in a brain. Progress in hardware, artificial intelligence, and software design has led to the development of a computer system that is able to "learn" to solve certain types of problems. The field of neural nets is in its infancy, but is showing promising results.

To summarize, we can predict with considerable confidence that computer CPU and primary memory hardware will become more and more powerful and that the real costs of a given amount of compute power will continue to decline quite rapidly. This trend will certainly continue into the next century. This means that any hardware one purchases now will be outdated in a few years. That difficulty, which has already lasted for four decades, will continue to be a challenge to educational leaders.

Besides raw compute power, rapid progress continues in secondary storage devices and in input/output devices. A brief discussion of each of these areas follows.

Secondary storage is making very rapid progress in magnetic storage devices, optical storage (that is, laser) devices, and magneto-optical storage devices. Floppy disk technology continues to progress. The technology exists to mass produce floppy disk systems with more than 10 times the storage capacity of the current mass-marketed floppy disk drives. For example, in 1986 a five-megabyte floppy disk system was brought to market. In 1990 a 10-megabyte system was commercially available, and in 1992 a 20-megabyte floppy system was commercially available. However, the floppy disk drive market is dominated by a small number of "standards," and these are slow to change. Thus, in 1992 most floppy disk drives use a storage medium with a capacity of well under two megabytes. There is substantial room for growth, and we will likely see at least a doubling in the standard capacity over the next five years. We may also see increased acceptance of a 2.5-inch floppy disk drive, especially on laptop computers. The 1.8 inch 40-megabyte hard drive is now frequently used in microcomputers.

Hard disk systems are rapidly decreasing in price and increasing in capacity. The cost of an 80-megabyte hard disk system for a microcomputer is now under $500. One can purchase microcomputer hard disks with a storage capacity of 320 megabytes or more.

Flash-memory cards are emerging as a major competitor for hard disks in portable computers. These solid-state devices are extremely rugged. While their 1992 cost per megabyte of storage is three to four times that of a hard drive, it is expected that eventually their cost will decrease substantially and that they will come into common use in laptop and palmtop computers.

Optical storage technology is now a commercial reality. Initially videodiscs were used to store movies and television programs. One side of a disc could store 30 minutes of television. This amount of storage can hold up to 54,000 individual pictures, such as pictures of art objects or pictures taken through a microscope. By 1990 this capacity had been doubled, and there is still considerable room for improvement. Videodisc use is now beginning to be common in schools, and continued rapid growth in educational use is to be expected.

Many people own stereo systems that play audio compact digital discs. A somewhat modified version of these discs (called a compact disc-read only memory, or CD-ROM) can store computer data. The 550-megabyte CD-ROM system (the disc itself is only 12 cm—that is, about 4.72 inches—in diameter) has found many commercial applications. For example, poison control centers using laser disc systems find they can do better searches (using Boolean logic) and can access information much faster from such a system then they can from microfiche. ERIC is on CD-ROM. Books in Print is now available on CD-ROM, along with order information to aid in purchasing any listed book. A number of companies now distribute their catalogs to dealers on CD-ROM.

The cost of "mastering" a CD-ROM (that is, creating a master, from which multiple copies can be pressed) has declined markedly in the past few years. It is now about $1,000. Even in quantities of a few hundred, copies can be made for under $2 apiece. A machine for making masters using your own microcomputer became available in 1991 at a price of about $35,000. It is clear that the CD-ROM business will continue to grow quite rapidly.

The CD-ROM technology has also produced a system that combines text, audio, graphics, and video This makes possible the relatively low cost distribution of interactive hypertexts combining all four media. It is evident that this type of use will grow rapidly in education.

The technology for audio discs and for data disks can be combined in a single system. Such systems will soon become commercially available. Current predictions are that such combination systems (providing hi-fi, information retrieval, and a built-in computer) will find wide consumer acceptance. This will greatly increase the number of general-purpose computers available in people's homes.

Write once, read many-times (WORM) optical disc technology has been on the market for some time. One application for such technology is for preparation of large data banks that will be distributed (for example, by mail) to a number of sites. Another application is for archival storage.

The write/erase technology for magneto-optical disks has been commercially available for several years. It received a major boost when the NeXT Computer, produced by a company started by Steve Jobs, used it in place of the more common magnetic hard drive disk storage system. Initially such systems stored about 500 megabytes; now 1,000 megabytes is common.

In the input/output arena, there are two driving forces. One is to improve the human-machine interface for computer users. This can be done, for example, by suitable use of voice or sound output, voice input, graphic displays, mouse, glove, touch screen, pen-based input, etc. The second is to reduce the cost and improve the quality of "conventional" input devices and hardcopy output display devices.

The voice input problem has represented a considerable challenge to researchers in computer science. Significant progress has occurred. Disconnected speech systems (requiring a very short break between words) have been commercially available for quite some time. The connected speech problem, handling the way people usually talk, has proven to be a major challenge to researchers in artificial intelligence. It is now clear that eventually there will be systems that can process normal speech with considerable accuracy. While business applications are clear, imagine the applications to teaching reading and writing to young children! We will continue to see slow progress in this direction during the next decade. By the year 2000 there will likely be many children whose initial reading/writing formal instruction includes use of a voice input system.

The past few years have seen a strong trend toward high-resolution graphics displays (often with color) for microcomputer systems. The more expensive systems frequently used in science and engineering often have 1,000 by 1,000 bit-mapped displays. Top of the line displays have a resolution of 4,000 by 4,000. The computer can "turn on" any of 16,000,000 dots on its monitor screen! High resolution computer graphics, combined with the massive amount of compute power that can come from parallel processing, makes possible "real time" computer graphic animation. That is, systems now exist that can generate and display graphics fast enough so that full motion is achieved. The cost of such systems is declining rapidly, and this price decline will bring such systems into schools during the next decade.

Such full motion computer graphics has been helped by steady progress in data compression. Through the magic of mathematics and use of a lot of compute power, the amount of computer storage space needed to store a video signal can be compressed by a factor of about 100. With this level of compression, a 12-cm CD-ROM can store a 90-minute movie.

Humans have considerable skill at recognizing visual patterns and in processing information presented visually. Computer-generated motion graphics on high-resolution display devices adds a new dimension to the human-machine interface. It seems evident that uses of high-resolution graphics will continue to expand. More and more, students will learn through being immersed in computer-facilitated environments, virtual realities, that facilitate learning by doing.

Computer hardcopy output devices (impact printers and laser printers) continue to make rapid progress. In 1975 a computer printer that cost about $3,500 could print 10 characters per second, upper case-only. Now one can purchase impact printers that are more than 20 times as fast, produce much better images, handle graphics—and cost about a tenth Note also that several color impact printers are now on the market, and ink jet printers, both black and in color, are now readily available. While some additional progress can be expected in impact and ink jet printers, it won't be nearly as rapid as in the past decade.

Laser printers have now come to the fore. A laser printer uses a Xerox-type process. However, the image is created electronically under computer control rather then by reflected light. The past half dozen years have seen rapid decreases in price and a number of new products. Many people now own “personal” laser printers.

The most commonly used laser printers have a resolution of 300 dots per inch. This isn't quite as good as typeset materials, but is perhaps four times the resolution of typical dot matrix impact printers. A 1,200 dots-per-inch laser printer produces print quality comparable to typeset materials. Laser printers and their associated computer systems have spawned the desktop publishing industry.

Desktop presentation is still another Information Age industry. With proper equipment, one can create 35mm slides or overhead projector foils using a microcomputer. With a PC viewer or video projector one can present computer-generated displays in an interactive fashion. Eventually we can expect that most classrooms will be equipped with such facilities, much as most classrooms currently have an overhead projector. Note, however, that it takes quite awhile for a teacher to learn to make effective use of such an interactive, computer-based display system. Thus, it will likely take more than a decade before this technology becomes into everyday use in a typical classroom.

Software Trends

Software progress over the years has been steady, but certainly not as spectacular as the hardware progress. However, software progress will continue steadily for many centuries to come, long after hardware progress has slowed. We'll briefly discuss two aspects of software:

- Programming languages and operating systems
- Applications software

Rapid progress in programming languages occurred quite early in the history of computers. From the early use of machine language it was a relatively quick step to assembly language. Higher-level languages such as FORTRAN (developed 1953-1957) and COBOL represented major progress. (Higher-level languages are easier for humans to work with than are lower-level languages.)

Many other high-level programming languages were developed to fit the needs of specific groups of users. One interesting aspect of this is how long a language lasts once it gains a significant base of users. For example, FORTRAN is still alive and well, and the current versions are much better than the early versions. FORTRAN is still commonly used by scientists and engineers, and there are literally billions of dollars worth of software written in FORTRAN.

Since the late 1960s, there has been a strong trend toward structured programming languages such as Pascal and C. An individual programmer using these languages isn't much more productive than one using FORTRAN or COBOL. But teams of programmers can much more easily work together if they use the newer languages, and the resulting products are more maintainable. Errors can be fixed (debugged) with relative ease. In terms of maintainability and modifiability, structured programming languages have led to productivity gains by a factor of perhaps three to five.

The quest for still better programming languages continues. One result is Ada, which has received strong support from the United States Department of Defense. However, many professional programmers suggest that Ada represents a great leap backwards. The attempt to develop a language that will be "all things to all people" hasn't met with great success. This suggests that it's difficult to develop a general-purpose programming language that is clearly superior to existing languages.

Recent years have seen the development of object oriented programming languages. These show considerable promise for increasing programmer productivity. Chunks of code produced in an object oriented programming language are more readily used as building blocks in larger programs than are the chunks of code produced in other types of programming languages.

The initial progress in developing better operating systems paralleled progress in developing better programming languages. We now take such things as a timeshared operating system on a mainframe and mouse-based manipulation of files on a microcomputer for granted. In some ways we have witnessed a merging of programming languages and operating systems, such as programming in C in a UNIX operating system environment. The Macintosh series of computers and the Windows software for MS-DOS machines has demonstrated that the operating system can be made transparent to the casual computer user. At the same time, operating systems continue to grow in sophistication and complexity. This trend will continue.

Parallel processing provides a major challenge to computer scientists who specialize in operating systems. The goal is to have programming language and operating system aids to help the programmer effectively use these types of hardware systems. Progress has been, and is likely to be, slow.

Next we look at applications software. Here it seems that most computer users forget the progress that had already been made more than 25 years ago. By the early 1960s there were substantial computer libraries of scientific subroutines and statistical packages. Now, of course, such programs run on microcomputers and are more user friendly.

There seem to be three clear ideas in the computer applications area. First, any application running on a current mainframe computer will eventually be available on a microcomputer.

Second, all applications software gradually becomes more user friendly. It becomes easier to learn to use and easier to use.

Third, artificial intelligence is now producing a large number of aids to problem solving. This artificially intelligent applications software is increasing the range of problems a computer can handle. Many hundreds of such products have come to market, and more will follow. This trend will surely continue through the work of artificial intelligence researchers and as the needed compute power becomes more cheaply available. The challenge to education is immense. If a computer can solve or help solve a particular category of problems, what should students be learning about how to solve this type of problem?

Voice input, discussed earlier in this chapter, provides a good example of the educational challenge of artificial intelligence. Early voice input systems required the power of a mainframe computer system and took a minute or more to decipher a short utterance. Now there has been considerable progress in the theory of voice input, and computers have become both faster and cheaper. A microcomputer-based voice input system, able to handle disconnected speech at a rate of about 30 words per minute, became commercially available in 1990, and its 1992 price was well under $10,000. It is clear that voice input systems will gradually grow in use during the next decade. However, a commercially viable connected speech input system will remain elusive for the next several years.

Networking

As mentioned earlier, one characterization of the Information Age is better access to more information. The worldwide telecommunications system is growing very rapidly, aided by satellites, microwave systems, and fiber optics. Local area networks (LAN) are now common, and this type of computer interconnection is in a period of very rapid growth.

It's hard to appreciate the potential here. Fiber optics will eventually replace the copper wires now connecting our home telephones. The capacity of a pair of fiber optics, each as thin as a human hair, is thousands of times the capacity of a pair of copper wires. Fiber optics can support high-quality interactive color television. Currently a fiber optic cable is being laid across the Pacific ocean that can carry 600,000 simultaneous phone conversations.

Rapid progress is still occurring in fiber optic technology. For example, researchers are now beginning to produce optical integrated circuits. Such researchers talk about building optical computers that may be a thousand times as fast as today's computers. These will readily interface with the fiber optic telecommunications system, further aiding its versatility.

But that is many years in the future. More down to earth is the increasing carrying capacity of fiber optic cables. Recent research results suggest the possibility of a single fiber optic having the potential to carry ten million simultaneous two-way telephone conversations. This capacity would allow a full-length color movie (appropriately digitized, of course) to be transmitted in less than a second.

A combination of improved networking and improved large-scale database storage devices will have a profound impact on libraries and the publishing industry. We previously mentioned the 12 cm CD-ROM with a capacity of 550 million bytes. A single disc stores the equivalent of 500 very thick novels—or more than the number of books a typical student studies during four years of college! A handful of these discs can store the equivalent of a typical school library.

Thus, we are moving toward a distributed library with greatly increased information at the fingertips of the user. Eventually students will carry substantial libraries and easily portable computer, much like they now carry textbooks. The classroom will be networked to the school library, district library, university libraries, national libraries, and international libraries. An overwhelming amount of print, audio, and video materials will be available to students and teachers. This will support the hypermedia classroom, which will slowly become commonplace.

We must realize that libraries and the publishing industry are very large, relatively slow-moving institutions. They have started to adjust to computer technology; this change will be slow but steady. Already we can see significant changes in research libraries and in the storage/retrieval of literature to support research. Also, many libraries have replaced their card catalogs by computerized systems.

Computer Science

Computer science is now a well-established discipline. The Association for Computing Machinery first developed recommendations for the content of an undergraduate computer science degree in 1968. There are now hundreds of computer science departments at the college and university level. There are several competing national recommendations on curriculum and there are textbooks to support these recommendations. A very large number of college students are currently majoring in computer science. Interestingly, however, such enrollment in the United States peaked in the mid 1980s and has declined substantially since then. Perhaps students are seeing that computer science is both a hard major and no guarantee of a high-paying job.

During the past 30 years, we have seen computer science course content filter down from the graduate level to the undergraduate level and even into the precollege level. List processing and recursion in Logo, a language designed for elementary school students, certainly illustrate this point. The Logo language draws heavily from a programming language developed for use by artificial intelligence researchers and that was formerly the province of researchers and graduate students in computer science. The high school Advanced Placement course in computer science contains many topics that used to be studied at the advanced undergraduate level.

While the discipline of computer science is beginning to mature, it seems evident that rapid change will continue. An excellent example is provided by the Prolog programming language. A few years ago it was primarily of interest to graduate students and researchers specializing in artificial intelligence. Now it may be encountered in a freshman course for computer science majors. It has even been used with grade school students in a research project in England.

College and university computer science departments face an interesting challenge. As computer science matures, it becomes a more rigorous, mathematically oriented subject. It's a discipline that challenges the intellectual capabilities of people who are good at algorithmically oriented problem solving. But a major goal of computer science is to make computers easier to use, and rapid progress is occurring. Today's graphic artists, perhaps with no formal training in computer science, routinely solve problems that were at the frontiers of computer graphics only 25 years ago.

The question is: "Who needs to study computer science, and to what level"? At the current time there's no consensus on an answer. It's evident that computer science will continue to be a major field of study in colleges and universities. However, it could well be that the serious study of this discipline will decline at the precollege level. Certainly the serious study of computer science in high schools is no longer a growth area. Total enrollment in such courses declined substantially in the United States during the latter half of the 1980s.

Computers in Instruction Trends

Here we'll take two approaches, treating each somewhat briefly. In the first approach, we'll examine an overview of computers in instruction. There, the total field is divided into teaching/learning about, using, and integrating computers. In the second approach we'll look at instructionally-oriented software, instructional support materials, and teacher training. There are clear trends in all of these.

Learn and Teach About Computers. In the "About Computers" category we include the discipline of computer and information science, of which computer programming is a subfield. The key issue is what we want students to know about computers. We want to dispel the magic, and we want all students to have a mental model of a computer as a machine that can follow a detailed step-by-step set of directions that have been developed by humans. We want all students to have a reasonable level of knowledge about roles of computers in problem solving.

The heart of the matter seems to be the idea of effective procedure—developing and representing procedures designed to accomplish specified tasks. We want students to have some idea about what is involved in a carefully developed specification of a procedure (data representation, data structures, and control structures). We want students to understand how difficult it is to develop procedures, and that there are effective procedures being developed in every academic discipline.

We want students to understand roles of computers in problem solving in all disciplines. Most educational leaders suggest that we don't do very well in non-computer-based problem solving. Thus, we tend to confuse computer-based problem solving with the more general issue of problem solving. This general issue will continue to beguile educators indefinitely.

It's clear that some form of computer programming can be taught at almost any grade level. However, we lack solid evidence that the teaching of computer programming helps improve general problem-solving skills. That is, problem-solving skills learned in a computer programming course don't transfer automatically to solving problems in other courses or disciplines. Our increasing insight into transfer of learning and how to teach for transfer will gradually help to improve education.

We now know that if we want students to gain increased skill in writing programs to solve problems, we have to place more emphasis specifically on problem solving. Many people who are currently teaching computer programming courses aren't particularly qualified or trained in the knowledge and skills needed to significantly increase the emphasis on problem solving.

Our conclusion is that the above types of issues concerning teaching computer science and computer programming at the precollege level will remain unresolved during the next decade. Individual school districts will decide what seems best for their students. Eventually there will be sufficient research to answer some of the questions.

Computer-Assisted Learning. Computer-assisted learning includes drill and practice, tutorials, simulations, and microworlds. Much of the commercially available CAL material contains a record keeping, diagnostic testing, and prescriptive system—that is, a computer-managed instruction system. The large commercial CAL systems are often called integrated learning systems (ILS).

It's likely that we are at the start of a steady and significant rate of growth in use of CAL. Six factors combine to support this prediction. First, research evidence to support the effectiveness of CAL is quite strong and continues to grow. Second, declining hardware costs are making CAL more and more cost-effective. Third, there's an overall trend in this country toward individualization of instruction, and CAL supports this trend. Fourth, CAL can increase productivity of students and teachers. Fifth, the amount of CAL material is now of significant size and growing quite rapidly. Sixth, CAL is improvable; most of the time, newer software will mean better software.

We predict that CAL will gradually become a significant factor in the education of most students. We wouldn't be surprised to see that 15-20 years from now more than half of all precollege instruction in this country being delivered in a CAL mode. This suggests a major change in the role of teachers, changing from delivery of instruction to facilitation of learning.

Learn and Teach Integrating Computer-as-Tool. The integration of computer-as-tool into the curriculum is now well started. Many school districts have set goals of having all students learn to use a word processor, database system, and graphics package. The key idea is that such tools increase user productivity—the ability to solve problems. The evidence for increased productivity in the work place is overwhelming and is a core idea of the Information Age. This evidence seems to be motivating schools to change their curricula.

We know, of course, that it's difficult to make major changes in school curricula in a short time. Over the next two decades, those who understand and appreciate the potential of computer-as-tool will mount a major challenge to the inertia of our school system. It seems clear that eventually computer-as-tool will be thoroughly integrated into every academic discipline. This will require major changes both in curriculum content and in testing. Students will need access to computers during testing, and this will be a major challenge to the testing industry. Every teacher will need to become proficient in tool uses of a computer.

The Growing Software Infrastructure

Our second approach to predicting the future of computers in instruction is to look at instructionally oriented software, instructional support materials, and teacher training. The Educational Software Selector and its updates, published by EPIE, list about 12,000 pieces of software. It's clear that the average quality of educational software is improving. The market is now large enough to support a number of companies that specialize in educational software. The competition, as well as excellent leadership in some of these companies, is contributing to improvements in educational software.

Videodisc-based CAL is gradually growing in importance. A clear trend has been established, with leadership coming from business, industry, and military education. Some excellent materials are now available for use in the precollege curriculum and statewide "textbook" adoptions of such materials are now occurring. We predict slow but steady growth in videodisc-based CAL in precollege education. That is, we are still on the lower leg of the S-shaped growth curve for this type of CAL.

Some of the videodisc-based and other CAL materials are being designed to maintain the teacher at the center of the instructional delivery system. The teacher controls the videodisc system or a single computer being used for a computer simulation. The teacher facilitates class discussion and other activities. Relatively few teachers have been trained in such use of technology in education, so this suggests an area where extensive staff development will be needed.

The past few years have also seen the publication of a large number of computer-related books to support teacher training. Indeed, this market became saturated in the mid-1980s, and a number of companies canceled some planned products. In total, it seems clear that publishers are well aware of the potential for sales of computer-related instructional support materials. Indeed, although there's still plenty of room for high-quality materials, it feels like the quantity of materials already available is quite large. That is, this is now a maturing segment of the publishing industry.

The teacher training problem is quite large. In the United States there are well over two million inservice teachers, and their average level of computer knowledge and experience is still quite low. Most school districts recognize this problem, and the response of school districts throughout the country has been good. A number of districts have provided all of their teachers with introductory training.

Two things seem clear. First, the average level of teacher computer literacy will continue to grow steadily for many years. Second, this average level of teacher computer literacy will continue to be quite a bit lower than what computer education leaders might desire. Very few current teachers have grown up with computers. We still have very few students entering college who began using computers while they were in elementary school.

Conclusions and Recommendations

Many of the trends discussed in this chapter seem quite clear. The hardware price-to-performance ratio for computers will continue to improve quite rapidly, resulting in schools having access to much faster machines with much larger primary and secondary storage devices. Hardware will be connected to local, regional, national, and international networks, resulting in students having increasing access to information. More and better software will become available. Computers will solve or help solve an increasing range of problems. Artificial intelligence will grow in importance and in use.

In summary, access to information and aids to processing this information will increase many fold in years to come. The educational implications are profound. The discussion in this book leads us to offer 10 general recommendations. Their full implementation would lead to major changes in our instructional system.

Recommendation 1. Computer-assisted learning and distance education should be viewed as effective aids to learning productively. There should be considerably increased emphasis on CAL and distance education to make broader educational opportunities available to students, to facilitate more individualization of instruction, and to increase learning.

Recommendation 2. Computer-integrated instruction (computer-as-tool) should be viewed as an efficient aid to students at school, at home, and on the job. All instruction at all levels should take into consideration computers as an aid to problem solving and computers as a source of problems. The use of computer-as-tool should be integrated throughout the curriculum. Curriculum content and testing should be modified adequately to accommodate computer-as-tool.

Recommendation 3. Students should learn enough about the general capabilities, limitations, and underlying nature of computers so that the magic of computers is replaced by knowledge, a sense of familiarity, and a sense of being in control. In particular, students should understand and routinely use the concept of effective procedure (including the creation and representation of procedures, and procedural thinking). This concept is among the most important academic ideas of our century. Learning it is part of what it means to be educated for life in our society.

Recommendation 4. All schools should provide good access to computer-based information storage and retrieval systems. All students should be given instruction in use of such systems and should make regular use of these systems throughout their schooling. The total accumulated knowledge of the human race is growing rapidly. Learning to access and make appropriate use of this collected information is at the core of education.

Recommendation 5. Computer-as-tool should be viewed as an aid to teacher productivity. Every teacher should have access to a personal computer at work and at home. Almost every classroom should have a computer with large display screens or a projector to allow computer-aided interaction between teacher and class. All teachers should obtain general instructional computing literacy and a relatively deep knowledge on uses of computers within their own specific subject areas.

Recommendation 6. All preservice and inservice teachers should be given appropriate opportunities and encouragement to improve their abilities to function well in this changing environment. Computers affect teachers' roles. There is less demand for teachers to be the source of information and the delivery device. There is greater demand to be a facilitator—a role model as students learn "people skills" and higher-order thinking and communication skills. (Note that recommendations 5 and 6 pose a severe challenge to our entire preservice and inservice teacher education system.)

Recommendation 7. Educators should keep in mind that most real-world problems are interdisciplinary in nature. Schools should place increased emphasis on cross-fertilization among disciplines, on applications of one discipline to the study of a second, and on solving problems making use of information and ideas from several disciplines. The computer can help motivate this change in educational emphasis, and it is a valuable tool in carrying it out.

Recommendation 8. Computers are changing our world view, our metaphors, our ways of dealing with everyday issues and problems. We should be aware of ways computers are changing our world and not lose sight of important underlying values as we adapt.

Recommendation 9. Open and hidden curricula should change. Those concerned with developing or revising any existing course (or unit) should ask themselves:

- What problems can students solve as a result of learning the content and skills of this course?
- What roles can and should computers play in helping to solve these problems?
- How are and will these uses of computers affect students' lives, and what should the students be doing about these effects?

Recommendation 10. There should be a major shift toward authentic assessment. The goals of education and how one demonstrates "being educated" should be open and clear to students. There should be a substantial decrease in emphasis on closed book, timed, standardized tests.

These recommendations should contribute to three results fundamental to a successful society in the Information Age. All educators should be, and all students should become:

- Independent, self-motivated, self-sufficient, lifelong learners.
- Researchers, able to form and test hypotheses, and to make effective use of the accumulated knowledge of the human race.

- Self-confident posers and solvers of problems, well-versed in using their minds and such aids as computers.

Interviews: Introduction

Over the past two decades I have known a number of TCs. I have spent many hundreds of hours talking to TCs and other computer leaders about their work. This book reflects the general knowledge I have acquired about the TC position. While working on the 1985 version of this book, I increased the amount of interaction I had with TCs. In addition, I arranged to interview a number of leading TCs so they could report on the nature of their positions. I then interviewed the same people again as well as one additional person for the current version of the book.

The purpose of including these interviews is to give a general flavor of the types of people who are TCs, the work conditions they face, and what they accomplish. The names of the people being interviewed have been changed, and no attempt has been made to provide exact quotations as their responses to questions. Some attempt has been made to hide the identity of the school or district where the TC works. The first interview is a composite, representing several people.

Sample Questions Used in Fall, 1984 Interviews

1. Please give your title and describe your computer coordinator position. Include information about your administrative and fiscal responsibilities.
2. What is your educational background and work experience, both as a teacher and in preparation to be a computer coordinator? How did you come to obtain the position of computer coordinator?
3. What aspects of your computer-oriented training and experience have been most helpful to you?
4. What are the areas in which you feel you need the most work in order to improve yourself as a computer coordinator?
5. Describe what your school/district is doing in computer education. Include information about the amount of computer facility that is available and how it is being used. Also comment on computer-oriented inservice education and the general level of computer knowledge of teachers and administrators in your school or district.
6. Does your district have a computer plan? Do the schools in your district have individual computer education plans?
7. What role do you play in helping the school/district reach its computer education goals? How many hours per week do you work?
8. How do you and others evaluate computer-oriented progress in your school or school district? Is there an evaluation plan for the district or for individual schools?
9. How are you evaluated? To whom do you report (as an computer coordinator)? What do you do to maintain and increase your competence as an computer coordinator? In particular, how much time do you spend reading, trying out new software and hardware, and learning new things each week?
10. What is the most exciting part of your computer coordinator job?
11. What is the least fun part of your computer coordinator job?
12. Do you have an computer coordinator contract, or any type of job security as an computer coordinator ? Describe the nature of your contract.

13. What are the most important or the most critical decisions you have to make as an computer coordinator?
14. What do you consider to be the most important qualifications necessary do your job well?
15. What could the district computer coordinator or your immediate supervisor do to help you more? What could others do to help you? Do you have some sort of support group, such as a regional organization of computer coordinators that meets regularly?
16. What is your pet peeve about being an computer coordinator?
17. Do kids or teachers in your school make illegal copies of disks? How do you deal with this?
18. What progress do you expect your school or district to make in computer education during the next few years?
19. What role do you expect to be playing in computer education five years from now?
20. What else would you like to tell people who have computer coordinator positions or who are thinking about becoming computer coordinators?

Follow-up Interviews

The following questions were used in the follow-up interviews.

1. Can you share some of the changes that have occurred in your life and job during the past six years?
2. What changes for the better have you seen in instructional use of computers in the past six years?
3. What changes for the worse, or lack of progress, have you seen in the past six years?
4. What do you see happening in the future?
5. What words of advice do you have for a person who is now thinking about becoming a TC?

Middle School Computer Coordinator Interview

Position Description

Alice is a building-level computer coordinator in a small middle school of about 300 students and 16 teachers. She teaches mathematics two periods a day, computer literacy two periods a day, has one preparation period, and has one period of release time due to being the school's computer coordinator. The school day is six periods long and the usual teaching load is five periods. The school has eight single-user microcomputers in a classroom that is used four periods a day to teach computer literacy and computer programming classes. It has one microcomputer in the library. All students in the school are required to take a 12-week computer literacy course while in the sixth grade.

Alice is in charge of the computer classroom and schedules its use when it is not being used to teach computer courses. She works with the library-media specialist to organize the school's collection of software and she makes sure appropriate software is available to the non-computer teachers who want to make use of the computers. She meets about once a week with the school's computer committee which consists of four teachers. She meets once a month with the school district's computer committee.

Alice has taught computer courses and been the computer coordinator at her school for two years. She has also organized and taught two different courses for teachers. One was on Logo and one was on word processing. Each had 10 hours of class meetings, one evening per week for four weeks.

Qualifications

Alice has a bachelor's degree in mathematics and is currently working on a master's degree in mathematics education. She has been teaching for seven years in junior high schools and middle schools. Alice is divorced, with no children, so she can spend a great deal of time outside of school working with computers.

Alice first became interested in computers via a FORTRAN course taken while an undergraduate. Since then she has taught herself BASIC and Logo as well as word processing. Next summer she hopes to take a Pascal course as part of her master's degree work in math education.

Alice was instrumental in her school getting computers three years ago. She did this by attending a number of district meetings and convincing the district computer coordinator that her school would be a good place to pilot test a computer literacy course that might eventually be required throughout the district. Two years ago she organized and taught the first computer courses her school offered. She has managed to get other teachers interested and to get a 12-week computer literacy course required in her school. This is still an experiment, but likely the whole district will implement such a requirement next year.

Interview

1. *As the computer coordinator in your school, you get one release period per day. How much time per week do you spend on computer coordinator activities?*

In school I spend about two hours a day on computer coordinator activities. Actually, I spend more time then that, supervising the lab before and after school. But I can grade papers and work on lessons during part of that time. In addition, I attend meetings which average about an hour a day. I guess I spend about 15 hours a week.

2. *Please give more details on how you spend your time.*

Nobody tells me specifically how to spend my time. Some kids like to get to school early, in order to use the computer. Thus, I arrive a half hour or so earlier than most teachers. Similarly, kids like to use the computers after school, so I supervise the computer lab for an hour and a half after school. Those are my biggest time blocks.

I had the principal organize a computer committee, and it meets about twice a month on Thursday afternoons. We now meet once a month with some parents—on the first Monday evening of the month. In these meetings we talk about software, courses, goals and getting more hardware. The president of our school's PTA is on the committee, and the PTA is going to raise some money for us this year. Our school's library-media specialist is on the committee. She orders software for us. When it comes in, she makes an archival copy, catalogs the software, and puts it in a notebook. We have one microcomputer in the library, so that kids and teachers can try out various pieces of software.

The district computer committee meets on Friday afternoons, right after school, once a month. These meetings are fun because I get to learn what the other schools are doing and I learn about new pieces of hardware and software. Often several of us go out for pizza afterwards, and then we go on to the house of someone who has a computer and some new software. I am thinking about buying a computer for myself, as soon as I can save a little money. Right now my car needs some work.

3. *What is your school's computer budget situation? Do you have money to spend? And what are the bounds of your overall authority to act as a computer coordinator?*

Most of our school's hardware comes through block grant funds at the district level. We have one machine purchased with PTA funds and one we got using money the principal found. I have a budget of $500 per year for software; I think maybe this money comes from the district. I also have to buy ribbons and paper using that budget, but sometimes we use a different supplies budget for that. Money is definitely a problem; we need books, materials, and more software. If a machine breaks, the district fixes it. I just call the district computer coordinator's number and eventually it gets fixed.

Some of the teachers suggest that they know where I can get copies of software—they are talking about pirated stuff. The kids are always wanting to bring in stuff they got from their friends. I don't allow any of this to happen, but sometimes I think it might be okay. We sure do need more software.

The principal says I am in charge of the computer lab. I get to decide when it will be open and who can use it when classes are not scheduled. I am head of the school's computer committee; part of my job is to help decide what courses we should offer and how the computers should be used.

If people disagree with the way I am trying to run things, we usually take it to the principal. She seems to support me most of the time. She took a computer workshop two years ago and thinks computers are good things.

4. *Do you get extra pay for being a computer coordinator?*

No, I am on a regular teacher's contract. However, last summer all of us on the district computer committee got one week's pay to work on new courses. And the district paid my way to an out-of-state computer meeting last year. Also, I earned a little money teaching courses for teachers during evenings last year.

5. *Do you have a pet peeve about your computer coordinator work?*

It really bothers me that most teachers can't see how important computers are. They are willing to let me have computers and do all the work. But they don't try to learn about computers and use them in their teaching. And I don't like the way boys try to crowd the girls off the machines, and the girls just sit there and take it. Maybe this wouldn't happen so much if we had more machines and more teachers made use of them. I make sure that the girls in my classes get equal access to the machines.

6. *What else would you like to tell people about your computer coordinator work?*

Computers are what make my teaching job interesting. I teach computer classes two periods a day and I make use of computers in the math classes I teach. I spend a lot of time talking to teachers about computers. I spend time in the evening reading computer magazines and thinking about ways to use computers in school. I am planning to buy a computer. And it really would be fun to have a robot. I guess they cost quite a bit, so that will probably be a while.

I guess what I am saying is that computers are fun—they have made my teaching job much more fun. I am thinking about switching out of the mathematics education program into a computer education program and getting a degree in that area. If it weren't for computers, I guess I would be thinking about getting out of education. Now I think that I'd like to be a district computer coordinator. I guess that would mean moving on to another district, but that would be all right.

Follow-up Interview

A number of years have passed since the first interview. However, the school building has not changed much, and the increasing use of computers in the school has not greatly changed the basic nature of the curriculum.

1. *I see that you are still deeply involved with computers. Can you fill us in about some of the changes that have occurred for you during the past half dozen years?*

I am still a middle school teacher. In my master's degree work, I switched out of math education into computer education. I finished the master's degree. I looked for a district computer coordinator job, but didn't find one. In fact, I only saw a couple of ads for such a position in the whole state. I guess most of these positions don't get advertised outside of the district.

When you first interviewed me, I was teaching computer literacy two periods a day. The next year our district implemented a requirement that all students be "computer literate" by the time they leave the eighth grade. In essence, this means that they must take a half-year course about computers and their applications. Our school has grown, so we now have over 450 students. I teach all of the computer literacy courses, and that keeps me busy three periods a day.

It has been interesting to see how the computer literacy course has changed. At first it had a lot of programming in it. However, that did not work out very well when the course became required. So, we switched to computer applications. All students learn to use a word processor, database, and graphics. We use an integrated software package. I also have the students read a computer literacy book. It isn't very good, and it is out of date. I have developed quite a few handouts and found some magazine articles that I have the students use.

I don't get any release time to be the school computer coordinator. That seems strange, because we now have about 45 microcomputers in our school, and most teachers still don't know too much about how to use them. I get lots of questions, but the teachers have learned that they should not interrupt me when I am teaching.

I teach math two periods a day. I make use of computers in these math classes. We have a mini-lab cluster of four machines in the math classroom. I am bothered by the fact that the other math teachers in the building don't make much use of computers in their classes.

I have grown in many ways. I continue to attend computer conferences, and I am now a regular presenter at these conferences. I teach several workshops each year, and I have gotten into telecommunications. I have begun to experiment with hypermedia, and I regularly use a PC viewer in my classes. I have written two computer articles that got published. I have begun to think seriously about returning to school to work on a doctorate in the field of computers in education.

2. *I am impressed! It sounds like a lot has gone well for you. Have there been disappointments?*

   In retrospect, I am appalled at the little progress our school has made. Hardly any of the teachers in my building use computers. Besides myself, only one other teacher is into hypermedia. None of the other math teachers make use of computers. I still do some Logo in my math classes, but none of the other math teachers ever really got into Logo deeply enough to see how it could make a real difference for kids.

   Our school is doing better than average in the district. For awhile it looked like we would have strong district leadership and good funding for computers. However, budgets got tight and the district computer coordinator position was reduced to a half time position. It feels like computers are no longer very important in the district, and that other things are now much more important. We don't have very many district computer meetings any more. I miss these meetings.

3. *What do you see happening in the future?*

   I don't think that things are going to change much in my school in the next few years. It may be that the grass is greener on the other side of the fence, or it may just look that way. I know several teachers in another middle school in the state where I grew up, and lots of interesting things are happening there. They are into team teaching and interdisciplinary projects. They are into hypermedia, with students really doing interesting projects. They have a lot of computer music equipment, and one of there students won a prize for creating an original piece of music.

   I do a lot of reading, so I know that the computer field is continuing to change. I am thinking about a doctorate because I want to teach preservice teachers. I don't think our colleges of education are doing a good job in preparing teachers to deal with technology. I am sure that I could do better. I intend to apply for a sabbatical. If I get it, I'm out of here! I'll miss the kids, but I think it's time to move on.

4. *Do you have any words of advice for a person who is thinking about becoming a technology coordinator ?*

   I am convinced that computers will revolutionize education. At first I thought that the changes would occur quite quickly. Now, I know better. Fifty years from now people will look back at how "quaint" our educational system was, as computers were first being introduced. I can't imagine anything more professionally exciting than being involved in that change! I just wish it would happen faster.

Analysis

It is surprising to see so little change in the midst of so much change. Computers have gotten a lot more powerful and there are far more computers in schools, but this isn't making as much difference as one might expect.

This suggests how resistant our school curriculum is to change. If we look at business and industry we see massive changes based on computer technology. The private sector is able to see that appropriate use of computer technology increases productivity and decreases expenses. Companies gain a competitive advantage in this manner. Thus, the pace of computerization in the private sector has been rapid.

There is nothing in precollege education that corresponds to the "bottom line" in business. Public schools are not forced out of business if they fail to compete effectively. Thus, the major driving force for increased use of computers in business is lacking in education.

Many of the people who have spent years as computer coordinators are frustrated. They see progress, but they are bothered by the slow pace of the progress. A number of these people have left their TC positions. Typical routes include going back to a "regular" teaching position, going back to graduate school, or going to work in the private sector. However, many TCs are able to sustain their level of enthusiasm and are confident that they are spending their professional careers in a wise manner.

School District Computer Coordinator Interview

Position Description

Bill is a district-level computer coordinator in a school district of about 40 school building,,s 17,000 students, and 1,200 staff. This staff total includes administrators and many part-time teachers. The district has been involved with instructional use of computers since the late 1960s and in recent years has made a substantial commitment to increased instructional uses of computers. The district currently has about one microcomputer or timeshared terminal per 35 students, which is better than twice the national average. The high schools have the most equipment, middle schools have the next most, and elementary schools have the least. However, all schools are involved.

Bill's position is nominally half time as district computer coordinator and half time as inservice coordinator. These two positions are somewhat intertwined, and in both positions he reports directly to the assistant superintendent for curriculum. He has a full-time secretary. In addition, a half-time teacher and a full-time aide work under his supervision in the computer education area.

Bill arrived at his current position through first being hired as an elementary school curriculum coordinator and then gradually taking on more and more computer-related responsibilities. Eventually this change in duties was recognized, resulting in a change in his title and formal job responsibilities. Although nominally one-half time in each of two positions, he actually spends about two-thirds to three-fourths of his time in the computer area. Moreover, since he works about 70 hours per week, the computer coordinator position is actually a full-time job.

Qualifications

Bill has many years of teaching experience in elementary school. He has a broad liberal arts education, including a master's degree in a social science area. He has very little formal coursework in the computer field; he is mainly self-taught. He has been involved with computers for about five years and has owned a microcomputer for four years.

Bill has very good “people” skills. He has broad knowledge of curriculum. He reads computer magazines and journals perhaps 10-15 hours per week and attends many computer workshops, conferences, and presentations. He enjoys playing with computers and trying out computer ideas with kids. Bill is a family man and has made considerable (and successful) efforts to get his kids involved with computers.

Interview

1. *You mentioned that you spend about 50 hours per week in the computer area. How is this time used?*

The largest amount of my time is unscheduled. I receive about 30 phone calls a day. These come from teachers, parents, administrators, and from out-of-district people. Often I have to call back, since I am in a meeting or on the phone with someone else. Generally each phone call requires some action, such as meeting with a person, sending a person copies of material, referring the person to someone else, etc. The person who calls wants immediate action, so I am constantly being expected to respond.

I have formal, district-level meetings with groups of teachers or administrates about three times per week. These are usually a couple hours long. This is one way I disseminate information and receive input. And, of course, I have many meetings with individual educators and visitors.

During the day I have little time to myself. Thus, evenings and weekends are a relief. I generally read computer-related materials for two or three hours each evening, six days a week. My lack of a formal technical background in computer science probably is a handicap here, since I don't have a strong formal background to build upon. I am thinking about taking a sabbatical leave to study computer science education. But I am having so much fun on my job, I don't know if I would like to leave it for a year.

2. *Your school district has about one station of computer facility per 35 students. That is more than twice as many as the national average. What is the computer-related budget situation in your district?*

Our district spends about $200,000 per year for hardware, software, computer-related inservice education, my computer coordinator half time salary, half of my secretary, a computer aide, and a half time teacher who provides technical assistance to me. I have direct control over about $60,000 per year which I can use for hardware, software and computer-related inservice education. The principals in each school building have some discretionary funds. That is one reason we have uneven amounts of computer hardware in various buildings. Another reason is that the PTAs have purchased some computers. I can make recommendations and try to get principals to make certain decisions, but they directly control quite a bit of money. For example, a principal and the teachers in a building can decide to free up a teacher part time to serve as the building-level computer coordinator. They might do this by a slight increase in class sizes in the building. I can encourage this, but I cannot make it happen.

I have read your "Two-Percent Solution" editorial and used it with my supervisor and the school board. If we count everything, such as some building-level computer coordinators, we are at the one-half percent level. If budgets go well, we will more than double our computer expenditures for next year. Most of the increase will come under my direct supervision. Of course, if the budget situation goes badly we will have to drastically cut our computer-related expenditures, and I will probably be back in an elementary school classroom.

I am not sure we are ready for the "Two-Percent Solution" yet. If we had that much money a couple of years ago we would have spent it very poorly. It is easy to spend a lot of money, but it is hard to spend it in a responsible manner.

We are doing some things that don't take much money. We have identified one computer person in each school building. We encourage teachers to take computer-related inservice workshops and courses. We encourage teachers to study the computer field while on sabbatical leave. We have encouraged teachers and administrators to buy computers for themselves, and many have done so. A special purchase was arranged so they could buy computers at a good price. We loaned out some of our machines over the summer.

3. *What are some other good things your district has done in the computer field?*

We have done a lot of things. The district has developed goals which are broadly supported. We have adopted a software policy that strongly discourages piracy. The school board is interested in and supportive of our efforts. A number of our administrators have received inservice training and are supportive of instructional uses of computers. Our inservicing of teachers has been quite successful.

We have set up a computer resource center for the district. Last year it was staffed by a half-time aide, and this year by a full-time aide. We have a large and growing collection of software in this center. We spend about $9,000 a year for software for the center. We have a variety of microcomputers, so teachers can try out the software on the types of machines they have in their schools. We have multiple copies of some software for schools to borrow. We encourage the schools to buy software they need to use on a regular basis, but to borrow infrequently-used software.

We have good contacts with a nearby university. A number of their students get involved in computer-related projects in our schools. They have helped us evaluate some of our activities. The university offers courses that supplement and extend our inservice efforts.

Our district also makes substantial administrative use of computers. This has helped get some administrators involved with computers.

We are also interested in videodiscs. We own a half dozen videodisc players and we have one teacher who spends a lot of time in this area. We have exposed quite a few teachers to the potential of using videodiscs in instruction.

4. *You mentioned that a bad budget for next year might result in a substantial cutback in computers and in your job. Would you care to elaborate on that?*

I am not really sure about what sort of job security I have. I think I still have tenure as a teacher, and I have quite a bit of seniority. Right now I am in the administrator's collective bargaining unit, and I get paid on an administrative pay scale. I am on a twelve-month's contract. I am trying to get my position changed so that I am a full time computer coordinator. If budgets go well that may well happen. But if the budget situation is really bad, we will be laying off quite a few teachers. In that case I suspect that many of the curriculum coordinators and other specialists will be cut. I may be out of a job.

We do have quite a bit of computer facility in this district. In recent years we have put about half of our block grant funds into the computer field. But we have not established computers as a regular part of the regular district budget, with a major and continuing commitment. If the budget situation goes well, the school board might add several hundred thousand dollars a year to the instructional computing budget. The work we have done in the past is a solid foundation for that sort of increase, and I think we could use the money wisely. One of the things we would do would be to pay for some release time of a number of teachers, so that we would have a number of school building-level computer coordinators. They would be responsible for handling technical questions and problems arising in their buildings.

5. *Do you have a pet peeve about your computer coordinator work?*

I'm glad you asked that question. My peeve is that people don't understand my capabilities and limitations. They expect me to know everything and to be able to do everything. The typical situation is when someone phones me and describes a quite technical problem. It might involve a particular microcomputer, printer and piece of software. The assumption is that I am familiar with all of the details of every possible combination of microcomputer, printer and software. I can't possibly be responsible for knowing all these things, but I feel guilty because I don't know the answer.

6. *What are your main concerns about the future?*

I am worried about the budget. But even more, I am worried about how we are treating the building-level computer people. We have a number of teachers who are really dedicated educators and who are committed to working with computers. But we are expecting these people to do computer work and their full time teaching jobs. We don't give them any release time or other benefits. I fear that they will burn out and lose interest in computers. They will retreat back into their classrooms and we will lose a valuable resource.

7. *What are your main words of advice to district computer coordinators?*

I find myself torn between putting out fires and doing long-term planning and implementation. There are many fires to put out, and there is immediate satisfaction in putting out a fire. But I strongly recommend that you develop a support system that handles such details. The computer person we have identified in each school building, our plans to have building-level computer coordinators, and our current half-time technical expert are all part of our approach to this situation. The best thing a district computer coordinator can do is long-term planning and implementation. This needs to be based upon a substantial amount of program evaluation. The goal is integration of computers into the whole curriculum as an everyday tool for all students.

Follow-up Interview

1. *Can you share some of the changes that have occurred in your life and job during the past half six years?*

   My professional life is every bit as crazy, fun, and fulfilling as it was six years ago. I am now well into the final third of my chosen career and cannot imagine wanting to retire from this field! Every day contains the ridiculous ("Why won't this disk boot up anymore?") and the sublime ("How can we use this technology to help kids bridge into powerful meaning?"). Working with technology is at once thrilling, humbling, and maddening all wrapped into one.

   Probably the most important structural change occurred almost three years ago when my proposal was approved to move "Instructional Computing" into the District's Computing and Information Services (DP) group. It seemed to me that as long as the advocacy for computers in teaching and learning resided in the Instruction Department, that it would remain separate from the most important trend in technology in schools—networking computers together.

   Another important change related to this networking emphasis has been our push over the last couple of years to network teachers as well as computers. We've come a long way in the past several years toward the critical recognition that if students are going to become facile and competent technology users, then the same is true for teachers. AND that the teacher skills must precede the student skills. This point seems obvious, but our behavior during the first half of the ‘80s didn't reflect it We pushed computers too hard through teachers to the kids. Now we focus much more attention on teacher technology training, and not always for the direct benefit of students.

   Our district has a large Wide Area Network, originally intended for administrative communication (E-mail) and data processing for the usual business and student information record-keeping systems. Beginning about three years ago, we started a concerted push to get all teachers onto that network for the purposes of communicating with other staff and resource sharing. By now approximately 500 teachers in the district have VAX accounts, and both the number of teacher users and the variety of uses they make of E-mail are increasing rapidly.

2. *What changes for the better have you seen in instructional use of computers and related facilities in the past six years?*

   The change I've noticed most is a growing disenchantment with labs as the best way to deploy computers. Both our own elementary computer program and the research findings from Henry Becker at Johns Hopkins University pushed most schools into setting up a lab between 1985 and 1990. There is little argument that such a configuration is the most efficient way to make use of computers. But now the issue is whether it is the wisest way to do so. Labs allow for scheduling efficiency, but they take the computers out of the classroom, and consequently away from “real” school. If we really mean it when we proclaim computers to be tools, then it's not wise to store the tools in a place distant from the classroom, and available only during a certain time of the day (or the week!).

Another noteworthy change is that for at least the early adopters, computers are no longer “sexy.” By that term I imply that computers are no longer the hammer looking for a nail. The early adopters are by now much more thoughtful about using computers only when there is a clearly defensible use to which they can be put, rather than using them because they are available. The flip side of this observation, however, is that most teachers were not early adopters.

Perhaps the most hopeful change we are beginning to see is the use of computers by students and teachers for creating knowledge, *a la HyperCard* stacks and multimedia presentations. We must learn quickly how to distinguish between the glitz added by the technology and the substance of the knowledge created, but if schools can somehow nurture yet withstand this change, it could become revolutionary. It could also signal the end of public schooling as we now practice it.

3. *What changes for the worse, or lack of progress, have you seen in the past six years?*

   The most worrisome change I've observed is that too many principals are now dissatisfied about what computers are doing for their schools. I'll cast this observation a little too broadly to make the point clearer: many principals “overhoped” that computers would have miraculous effects on all students exposed to them even if only for a few minutes per week, and now finding this not to be true has turned their hopes elsewhere. I recently heard a nice metaphor to illustrate this phenomenon. A man wanted his car to be able to fly, but rather than deconstructing his clunker and restructuring it as an airplane, he simply paid a lot of money for a set of wings that he patched onto the old car's body. And he was quickly disappointed that his winged car couldn't fly.

4. *What do you see happening in the future?*

   I am fearful because the stakes are very high, increasing pressures from all the school's publics, expectations that are becoming unrealistic, and eroding resources. There is a growing perception held by both the public and the profession that things have gone profoundly wrong in public education. The very institution is at risk. And Americans have an unquenchable lust for the quick fix, most often manifested in new technology hardware. So we keep adding flashy new wings to the old car, provided by both expectations and (irresponsible) promises that the new ornamentation will somehow make that car fly.

5. *What words of advice do you have for a person who is now thinking about becoming a technology coordinator?*

   I would advise that person to be first a teacher, this admonition having both an ideological and a practical base. The former comes from a belief that only an experienced teacher can truly comprehend the incredible complexity inside today's classrooms. And the latter stems from my fear that declining resources will mean that lots of technology coordinators will be reassigned to classroom teaching when funding for their technology position FTE shrinks.

Analysis

Bill is the type of TC who helps build my faith that computer-related technology will eventually make a significant contribution to education. Over the years he has grown with the job, flexed when times were bad, and kept his eyes on the goal of improving education. He knows education, he knows teachers, and he knows students. He is always supportive of the progress that is occurring.

Bill's school district continues to be well above national averages in terms of the amount of computer facility available to students and staff. Moreover, his school district continues to seek out and implement innovative applications of these facilities. The current push is toward still more networking and getting kids onto Internet. This in being done in the face of relatively tight budgets.

It is clear that Bill sees the need for much more staff development than is currently available, and that he has helped make available a great deal of staff development opportunities.

Large School District Computer Coordinator Interview

Position Description

Charles is supervisor of instructional computer services in a Midwest school district of about 32,000 students. He describes his district as urban-suburban, largely middle class, with about twenty percent minority population. The district has been deeply involved with computers for quite a few years. Its hardware approach has been a combination of timeshared systems and microcomputers. The timeshared systems are all DEC machines and the microcomputers are mainly Apples. Currently the district has about one microcomputer or timeshared terminal per 35 students, which is better than twice the national average. The elementary schools have five to 16 microcomputers each, depending on school size. The middle schools each have about 25 microcomputers. The high schools have both microcomputers and terminals to the timeshared systems.

Charles has two full-time computer coordinators, an administrative assistant and a secretary working under him. It terms of the overall district administrative organization, Charles is at the fourth level. A superintendent, deputy superintendents and program directors are above him. However, he is on a 12-month contract and is paid on an administrative pay scale.

The overall approach to computing in the district is centralized. Planning and purchasing decisions are made at the district level. There are no computer coordinators in individual schools; indeed, there has not been an identification of "building leaders" in computing in the individual schools. The school district has an instructional computing plan, but individual schools do not have their own plans. Even the efforts to have the magnet schools develop their own plans have not been particularly successful.

Qualifications

Charles' undergraduate work was in physical education and mathematics education. He became a secondary school mathematics teacher and continued his academic studies. He now has a master's degree in mathematics education, about 20 credit hours in the computer field, and miscellaneous other credits. He has considerable experience as a mathematics teacher, as a mathematics specialist at the district level, and in his current position.

Charles is a soft-spoken, dedicated educator. He is deeply committed to improving education by working through our public school systems. He is a leader in computer education in his state and has considerable involvement at a national level. He works about 50 hours per week and is currently taking a Pascal course to improve his skills in structured programming and Pascal.

Interview

1. *You mentioned that your district has set goals for instructional use of computers. Please tell me more about these goals.*

During the summer of 1983 we had a committee of teachers and coordinators. I got things started by generating a first draft of a plan. The committee provided feedback and expanded the plan. The plan is quite comprehensive and served as a basis for a substantial amount of inservice work we did last year. It takes the approach of integrating computer usage throughout the curriculum, and it also addresses issues such as Logo. Last year we provided inservice sessions on each major part of the plan. If the total amount of inservice had been evenly distributed over all teachers in the district, it would have averaged about eight hours per teacher. Of course, we didn't reach all teachers, and some teachers have participated much more deeply than others.

The approach we are taking to instructional computing is to integrate computer use into the curriculum at all levels. We have put a number of microcomputers into each elementary and middle school, and we provide instruction in using these as tools. All of this is being done by regular classroom teachers. It is only at the high school level that we teach computer programming and computer science courses.

You previously asked if individual schools had discretionary money to purchase computer equipment or had developed their own instructional computing plans. The answer is no. Our district takes a central planning and purchasing approach. We distribute the computer equipment in an equitable manner. You also asked about computer coordinators or identified leaders at the individual school level. This turns out to be difficult, because it is a union-related issue. The union and the administration cannot agree on the identification of specific teachers nor on possible modification of their job descriptions or duties. Thus, our schools do not have computer coordinators. However, some principals have informally identified teachers in their schools to whom they can turn for help in answering computer-related questions.

2. *Please tell me more about the teacher training going on in your district.*

   We are doing quite a bit. Last year we provide 14,000 teacher-contact-hours of instruction. A teacher goes up one notch on the pay scale for each 50 contact hours of inservice work. We probably reached 400 or 500 teachers last year. The state is also doing introductory training. I think they have a goal of reaching 18,000 teachers this year. The legislature appropriated money for this. And many teachers take courses on their own. When I got this job about five years ago, I was probably the most computer knowledgeable teacher in the district. Now there are quite a few teachers who have more technical knowledge. That is one reason why I am currently taking a Pascal course. I need to improve my technical skills so I can continue to provide effective leadership.

   Your question raises an interesting point. We don't know which teachers have received computer training. This year we are creating a data bank of teachers and their computer backgrounds and experiences. It will allow us to see what inservice opportunities need to be provided. One of the things we stress in inservice is the ethics and the software piracy issue. We help teachers to understand what is wrong about stealing software. I think we have done a good job here even though many teachers have not been in our workshops.

3. *The data bank of teachers and their computer-oriented qualifications will be useful in evaluating the inservice program that you run. What else are you doing to evaluate progress of instructional computing in your district?*

   We measure the percentage of time that our hardware is being used. That is easy with the timeshared terminals, and we have also been able to determine utilization factors for our microcomputers. We have used survey instruments with teachers, mainly to determine whether they feel the district is providing appropriate and enough hardware and software, and whether the teacher training opportunities fit their perceived needs. We count the number of computer courses being offered in the high schools and the number of students taking these courses. We also do informal evaluation by talking to lots of teachers and administrators.

   One of our administrators went to a workshop on how to evaluate the effectiveness of inservice programs. He came back and interviewed a number of teachers about their inservice experiences. He discovered that the inservice they were receiving was not effective in producing change in the classroom. I now have a copy of Graham Ferres' doctorate dissertation in which he investigates how to do effective computer inservice education. That has been very useful to me, and it, along with the interviews done by our administrator, has caused us to change our inservice approach.

4. *What are the most exciting and fun parts of your job?*

   I like the excitement of the whole field. I visit schools, and I see the teachers are active, involved, excited. I see that the kids are having fun and learning. I get lots of positive strokes as I do my work. People appreciate the help I provide them, and I can see that I am doing a good job. We have come a long way in the past five years, and I feel good about the contributions I have made. I also enjoy long-range planning. I enjoy listening to and reading the projections of educational futurists, and then trying to bring some of their ideas into reality.

5. *Could you speculate a little about what you will be doing five years from now?*

   I expect I will be doing the same things that I am doing now. I will continue to be active in computer organizations at the local and national level. I certainly don't expect my job will go away during that time. I suppose it could, if we have a terrible budget crunch and if the individual schools begin to have computer coordinators. Good success in the full integration of computers into the whole curriculum may decrease the need to have a person in my position. I guess if worse comes to worse I can always return to the classroom. I have tenure as a teacher.

6. *Are there things about this job that bother you? What is your pet peeve?*

   I don't like to do paperwork. I would rather be interacting with people—with teachers and students. But more and more I find that I am tied to my desk. Another thing that bothers me is the difficulty in interacting with the district leaders in social science, language arts, science, business, industrial arts and so on. Each of these areas has a committee, generally consisting of secondary school department heads. I don't seem to be able to establish an effective dialog with these groups. Each group seems to contain its share of people that don't want to see any changes in education.

   I don't feel that I have enough time to do all the work I am supposed to do and also keep up in the computer field. I feel that I am falling further and further behind in technical aspects of the computer field.

   My pet peeve is the teacher who claims to be a professional, but teaches the same thing in the same way every year.

7. *What do you feel are the most important qualifications for a computer coordinator? What else would you like to tell people who are thinking about becoming computer coordinator?*

   The most important qualification is being a good listener. I would rate interpersonal skills at the top of the list of necessary qualifications. Getting people to work with you, getting them to help accomplish the goals, that is most important. Next I guess is the ability to do long-range planning. That is especially difficult in the computer field, because things are changing so rapidly. Both teaching and administrative experience are essential. Seek out new opportunities, such as teaching teachers, serving on committees, and doing long-range planning. These will all help you to be a good computer coordinator.

   My advice to computer coordinators is to not be afraid to ask questions. Don't be afraid to admit you don't know something. Talk to people, find out what they know, seek sources of information.

Follow-up Interview

Charles provided brief responses to five interview questions.

1. *Can you share some of the changes that have occurred in your life and job during the past six years?*

   So many things happen each year that it is difficult to remember what it was like two or three years ago, let along six years ago. The fact that there is more hardware and software now than there was then has made the decision-making process more complex and thus, more time consuming. I feel that the decisions I must make are far more complex than they were six years ago.

   I guess that there is some good and some bad to this change. The rapid changes that occur in hardware have made it difficult to stay anywhere near current. Plus, we now have such a wide range of computers—from Apple II+ to Macintosh IIs—and software to support. I sometimes feel overwhelmed by the pace of change—the number of new products that are announced each week.

   Many more teachers are involved in using computers, but my staff has not grown. This means that the same size of staff is now supporting three to four times the number of users that we did six years ago. It's a busy group. And, I'm getting older at the same time the job is getting harder.

2. *What changes for the better have you seen in instructional use of computers and related facilities in the past six years?*

   I believe we are making better use of computers today than six years ago. The movement of the focus of instructional computing from computer literacy to CAI to problem solving and higher-order thinking skills is a positive one. We still have aspects of the computer literacy and CAI focuses, but they are not as significant as they once were. The newer software gives the students much greater control over the systems. This places students in a learning environment different (and better) than the past.

   Although we have a long way to go, a number of teachers have improved their understanding of the role of technology in instruction and learning. These teachers do a "nice" job with the technology they have. They have developed a focus on problem solving and on helping students to use computers as a tool in doing tasks that require higher-order thinking skills.

3. *What changes for the worse, or lack of progress, have you seen in the past six years?*

   Many teachers are trying to use technology to teach using the same methods and the same topics as before. Many educators haven't found that the issues are greater than simply using technology. For example, they have not moved toward use of computers as an aid to facilitating cooperative learning and students working on large, interdisciplinary projects.

   And district staff development efforts have not been sufficient enough to change their thinking. Some educators still believe that technology, by itself, will make a significant difference in education. They don't seem to realize that the role of the teacher is critical to the effective use of technology.

4. *What do you see happening in the future?*

   More computing power; more and better software; more teachers involved. Many teachers will still be teaching the "old" curriculum with "old" methods and new technologies.

   For many teachers, I don't see enough staff development and support services time being provided for them to make the necessary changes in their teaching methods. Most educators have little appreciation for the work that it takes to change instructional methods and curricula. My staff is not large enough to provide the level of help that teachers need.

5. *What words of advice do you have for a person who is now thinking about becoming a Technology Coordinator?*

   Be prepared for a long uphill battle in getting technology appropriately used.

Analysis

Charles is a highly capable technology coordinator. Both the first and second interviews show a great deal of concern for individual teachers and the difficulties that they face in dealing with rapidly changing technology.

The interview points out two major difficulties faced by a TC. First, the pace of technological change has quickened and is an increasing challenge, even to a highly qualified TC. Second, there is growing awareness that the level of support that teachers need to restructure the curriculum (both content and teaching methodology) is far more than a typical school district can provide.

The new result is that being a TC is frustrating. The potentials for improving education are immense, but the actual pace of change is very slow.

Rural County Computer Coordinator Interview

Position Description

Doris is a microcomputer education specialist in a county school district that has about 450 teachers and serves about 9,000 students. The district is largely rural, with many of the students traveling considerable distances by bus. There are eight grade schools, three junior high schools, and three high schools in the district. The district has about one microcomputer per 80 students, which is roughly the current average for the United States.

The school district has recently undergone a 20 percent budget cut, due to the failure of a tax levy. The 20 percent cut completely wiped out all funds for new computer hardware, software, and teacher training. It came upon an already tight budget, in which services have gradually been cut. This recent drastic cut removed all funds for bussing students to and from school, as well as all funds for field trips, athletics, and other co-curricular activities. Doris retained her position only because it was funded by a federal block grant; her position will be eliminated next year unless there is a significant improvement in the budget. Essentially all teacher aides, many secretaries, a number of temporary teachers, and other support personnel were cut.

Doris is on a teacher's contract, both for pay rate and length of contract. She is in the teacher's bargaining unit and is excluded from the inner circle of school district administrators. But teachers view her as an administrator, which tends to cause her to be excluded from the inner circle of teachers.

Qualifications

Doris did her undergraduate work in elementary education and was an elementary school teacher for many years. She then did a master's degree in special education and a doctorate in school psychology. While in the doctorate program, she became interested in computers. She took a number of computer education courses, but with minimal emphasis upon computer programming and computer science. Much of her computer knowledge has been gained on the job, and she is currently sitting in on a Logo course to supplement her knowledge in this area.

Doris is a dedicated and very hard working educator who particularly likes to work with children and with elementary school teachers. She works at least 60 hours per week, and continually volunteers to take on additional tasks that will help students. At the time of the interview, she remarked that she had not been home before nine o'clock in the evening in the past week.

Interview

1. *The recent budget cuts seem to be underlying much of our conversation. Would you care to say more about this?*

   During the past couple of years our school district has made a lot of progress on teacher training, integrating computers into the curriculum, and working to use computers to improve the educational system. Now most of that has been put on hold. My initial budget of $125,000 was cut to zero. We were planning to spend about $10,000 on software, $15,000 on teacher training and $100,000 on hardware.

What really saddens me is that a group of community leaders have gotten together and are raising money to fund the athletic program. That program is continuing at a time when many students can't even get to school because there are no school busses! The athletic program and bussing cost about the same. Some parents are spending as much as three hours a day driving their kids to and from school. It is a particular problem for parents who have kids in several different schools, such as in a junior high school and a high school. These schools are widely dispersed in our county.

On the brighter side, our parent volunteers are working harder than ever. At the elementary school level they are deeply involved with the educational process. I believe that is a part of the "third wave" movement.

2. *No other computer coordinator I have interviewed has been as successful as you in making use of parent volunteers. Please describe some of the things they are doing in your district.*

Our parent volunteer efforts are mainly successful at the elementary school level, and I have had a lot of help in making it work. The Parent/Teacher Associations have been very active in fund raising to purchase computers. We have trained a number of parents to serve as computer aides. They have taken over the initial computer familiarization instruction given to all students. They are also teaching keyboarding and supervising students using computer-assisted instruction materials. Our large elementary schools have about 500 students. In some of these schools the total volunteer effort is equivalent to two full-time people. Not all of the volunteer work is with computers, but that is a major area.

I hold regular training sessions for parents. I have close contacts with the PTA groups, and they are quite supportive of our computer education efforts. We also have computer fairs for parents. Last year we had one large computer fair, for the whole district. I feel that it would be much better to hold individual computer fairs in each school, and that is what I plan to do this year. Parents, especially with elementary school children, seem to identify with their community schools. There is a ground swell of support for education, and especially for computers in education. This is coming from the parents, not from school administrators or school board members.

3. *The volunteer work parents are doing helps to implement your district computer plan. What is that plan?*

Our goal is to integrate computers as a tool throughout the curriculum, using computers to help improve the overall curriculum. Computer-assisted instruction is used mainly in a remedial fashion. The overall plan starts in the first grade with initial familiarization, mainly treating the computer as another manipulative. In the upper elementary school grades we do a lot with Logo and word processing. Our goal in word processing is to have students leave the sixth grade with appropriate keyboard skills and a typing speed of about 25-30 words per minute.

The Logo is a particularly difficult implementation challenge to our educational system, because our system tends to think in terms of scope and sequence. Many of the students have computers at home or go to computer camps. Our typical teacher who has received computer inservice training has completed 10 hours of inservice. A traditional scope and sequence will not work in this situation. Instead, we have developed a number of levels of Logo knowledge and related activities. We have task cards that students can follow. Our teacher materials assume an absolute minimum of computer knowledge. I view the elementary school Logo program mainly as a supplement to our art and math programs, and as an aid to developing the feelings of independence and power associated with being in control of a computer language.

At the junior high school level we have a conflict between teaching BASIC programming and teaching Logo programming. Many teachers were in favor of BASIC, but they didn't know Logo. I arranged a Logo inservice and there has been a gradual swing to Logo.

In our senior high schools we have programming and advanced placement courses. We use microcomputers in our business courses, and we are starting to push for use in the writing classes. We don't have enough equipment for this, but we have done planning and some teacher training.

We are now working on long term planning. It is not a scope and sequence plan. Rather, it is an integration into the curriculum, using computers as a tool to enhance the current curriculum and to help accomplish our district goals for education.

4. *Please tell me more about your approach to teacher training.*

   I have given teacher training the highest priority. We have developed a cadre of 20 teachers. Last year they received small payments to teach 10-hour courses to other teachers. We reached nearly half of the teachers in the district. However, this amount of training is quite inadequate for what we are trying to accomplish. That is why our initial budget for this year contained nearly $15,000 for additional teacher training. That would have paid the trainers, including funding some workshops run by people from outside the district.

   I have a list of every teacher in the district and the computer inservice training they have received. I work with principals to get their teachers into appropriate inservice activities. Each school has a computer committee, and parents are actively involved at this level. We have a district computer advisory committee with a representative from every school, some administrators, some parents and a few other key district personnel. It meets once a month. The district committee has three subcommittees. These work on hardware, software, and inservice training. Every member of the committee serves on a subcommittee.

5. *Do you have a district computer resource center?*

   We don't have a central hardware resource center. Hardware is in short supply, so we want to put all we have out into the schools. We have a substantial collection of software. Schools can borrow a piece of software for up to six weeks. Incidentally, we have a very strict policy on copying software. We absolutely do not allow it. That is built into all of our teacher inservice work and into the instruction students receive.

   Each school has a software collection under control of the librarian. Individual schools spend some of their own money to add to their software collections.

6. *What aspects of your previous training and experience have been most helpful to you as an computer coordinator ? In what areas do you feel least prepared?*

   My background in learning theory has been most important. For me, computers are just an educational tool. I want to appropriately use them in the overall curriculum. To do this I need to know the overall curriculum and the process of learning/teaching. My graduate work and teaching experience has been very helpful. As a graduate student I learned about educational research and evaluation. This has been quite useful knowledge.

   The job of being computer coordinator requires excellent interpersonal relations and communication skills. Many educators have these skills, but relatively few people with strong technical backgrounds have them. There aren't very many people like you who can bridge the gap, working well with both technical and non technical people.

   There are two areas where I feel I need more work:—hardware, and systems software. If a teacher has trouble booting a disk or accomplishing a more difficult task, I often don't know enough to tell if the problem is hardware or software. I am not very experienced with systems software, utilities, copying programs, and so on.

Budgeting has not been a problem It seems to be common sense. If I have troubles I know where to get help.

7. *What is your district doing to evaluate instructional use of computers?*

I rate evaluation as one of the most important things an computer coordinator can do or arrange for. We claim that computers are making or will make a significant contribution to education. But where is the evidence? My doctorate dissertation looked at special education students using computer-assisted instruction materials. When we use CAI, we should be able to measure whether this is an effective use of student time and the money spent for hardware and software.

We are evaluating our keyboarding and word processing program. How rapidly and accurately (i.e., number of sentences generated in a given amount of time, spelling errors, punctuation errors) can students write by hand prior to their keyboarding instruction? How well do they do using a word processor after a given amount of instruction and practice? Do their pencil and paper skills change as they learn to use a word processor?

8. *What are the most exciting and least exciting parts of your job?*

It is very exciting to see that computers are being used and that they are a focus for change in the overall educational system. There is a ground swell, led by parents and by many teachers. Parents are involved, and they want their children to get a good education. We have been able to focus this involvement into having parents serve as volunteer aides, serve on committees, and help raise money. I am also excited by the planning we do, and progress toward accomplishing our goals. Our educational computing is not just hit and miss, but is carefully designed to improve the quality of each student's education.

The least fun part of my work is that the job is too big. I work very hard, but there is so much to be done. See this stack of journals sitting on my desk? That is the reading I haven't had time to do this fall. Also, I feel isolated. With our budget cuts, I don't have funds to go to professional meetings or to bring in outside experts to run workshops.

Another part of the job that I find particularly frustrating is dealing with educators in the district, including administrators, who have very little computer knowledge. Last year I was evaluated by an assistant superintendent who was so busy that he didn't have time to learn about computers. He tried to be supportive, but some decisions were made from the top down to my office without research or a sound base of knowledge. At the individual school level some principals take an active interest in the computer field, encouraging their teachers and getting involved themselves. In these schools we are making good progress. In other schools the principals are not involved, and this makes progress much more difficult to achieve. My pet peeve is the latter type of administrators.

9. *What else would you like to tell people who are thinking about becoming computer coordinators?*

Don't use computers unless you believe that computers can do the job better. *Better* might mean that students learn faster, retain their knowledge longer, and have improved attitudes. Keep data—evaluate what you are doing. I believe very strongly in an infusion model; computers are an important new tool, and we want to use them to improve our educational system. We must collect data on whether computers are improving education and to help us make appropriate decisions on computer usage.

Follow-up Interview

Doris is no longer a computer cordinator. She left public education, moved to another state, and secured employment in the private sector. There she continues to make use of her educational experience, her knowledge of the computer field, and her research skills.

1. *What have you been doing since you left your computer coordinator position?*

After leaving my position as computer coordinator, I moved to a large metropolitan area and became the program director for a therapeutic day treatment program for emotionally disturbed school aged children. The program was designed to provide therapeutically based schooling for youngsters too disturbed to profit from public education.

It was a challenging position. One of my goals was to provide a computer lab and training for interested staff. Initially there was tremendous resistance, not to the idea of computers, but to the fact that with individual, group, and family therapy taking up so much of the child's day, it was difficult for the teachers to provide any continuity of curriculum. Time appeared to be the factor of concern, and the idea that computers could assist a busy teacher seemed to them to be administrative rhetoric.

For the first year of my tenure, the computer lab, such as it was, remained relatively idle. However, one by one, as the staff saw how non-threatened and how captivated many of their difficult-to-reach and difficult-to-manage students were by both CAI and Logo, they began to make time to take training and to use the computers. Now there is a fully stocked computer lab and a computer in every classroom. The computer lab is used extensively; both students and staff are highly enthusiastic about computers.

2. *What has happened in the school district that you left?*

Since the original interview, the school district has gained 500 students and continues to gain enrollment at an alarming rate. No new school buildings have been built and the district will need to consider double shifting or another alternative to handle the increased enrollment. Failed school budgets and bond issues continue to drain staff energies toward fiscal management rather than curricular activities.

As of the beginning of the most recent school year, a full-time computer education position no longer exists. It speaks well of the school district that this position has been maintained so long, in light of the very tight budget situation the district has been facing. The duties of the computer facilitator have been assigned to a person who has other (full-time) responsibilities. One gets the feeling that this decision was based purely on financial necessity and that the district ideologically continues to support computer use in schools. The budget for computers is about half of what it was during the first two years when I was building the program. Essentially all of the current funds are coming from a Chapter II (federal) grant.

The parents are still highly involved in computer education, especially at the elementary level where one PTA raised funds for an entire computer lab. The emphasis is changing as the software base widens. For example, the commitment to teaching keyboarding at the elementary level has faded with improved computer assisted software. Logo has not maintained its importance. The teachers are still being assisted in the computer labs by trained parent volunteers.

Currently the district has goals to provide a computer to every teacher so that teachers and administration can be linked. In fact, IBM is currently doing a district-wide study to help the district achieve this long-range goal. It is also a goal to provide databases to libraries so that students can access information for the purposes of research and report writing.

At this time, the hardware used is mostly a combination of Apple and IBM. There is a move afoot to put the Apple IIe computers into the elementary/junior high schools and to begin purchasing Macintosh computers for the secondary schools. The exception to this plan is that the business departments at the secondary level will continue to use IBM computers.

In summary, while it seems the computer program has lost some of its steam, the reason has more to do with budgets rather than disillusionment or lack of belief in the necessity of computer education. It seems positive that long-range planning is being done and that parents are still involved. I am optimistic that when the economy improves, the schools will put more resources into computers and computer-related support services.

Analysis

Adjusted for inflation, school budgets are actually declining in some parts of the country. Taxpayer revolts have caused class sizes to grow, teachers' salaries to be frozen, inservice activities to be curtailed, and so on. At the same time, the deteriorating social system in our country is forcing schools to spend more and more of their efforts on providing non-instructional services. Strong arguments can be made that the deteriorating home social situation is at the heart of many of our educational problems (Caplan, et al, 1992).

Many school districts have put a great deal of money into computers and computer-related support services. As budgets become tighter, there has been a tendency to decrease the computer-related support services and to delay purchasing new computer facilities. Thus, in many school districts the overall potential impact of computers in instruction is actually declining. In still more districts, the gap between the state of the art and what facilities and uses are actually implemented is growing.

Small School District Computer Coordinator Interview

Position Description

Rebecca is a Coordinator of Program Evaluation and Educational Computing in a city school district of 5,000 students located in the southern part of the United States. The city has one high school, two junior high schools and six elementary schools. It is a modest-sized city, but is the home of a major university. The presence of this university makes for a bimodal distribution of students, perhaps a classical "town and gown" situation. The city has between 20 and 25 percent minority population.

According to her job description, Rebecca's working duties are evenly divided between program evaluation and computer coordinator activities. Each could well be a full-time position, and she tends to give the computer coordinator position more than half of her time.

The school district has about 120 microcomputers, which is about one machine per 40 students. Most of this equipment was obtained through use of Parent/Teachers Association funds and from grants. Some of the grants are research projects being done in cooperation with the university.

Qualifications

Rebecca taught for about five years as a first grade teacher. She then took time off from teaching to begin raising a family. In 1976 her family bought a Sol microcomputer kit and put it together as a family project. This got her hooked on computers.

Since then she returned to school, first taking three computer science courses and then completing a master's degree and all of the coursework for a doctorate in educational psychology. She worked part-time as a paid aide, consultant, curriculum designer, and as an instructor of computer education courses—all while continuing her university education. Her university education qualified her for the position of Coordinator of Staff Development and Program Evaluation, which she obtained a little under two years ago. Her school system recognized a need for someone to provide direction in educational computing, but lacked funds to designate the position as an computer coordinator position. Her computer background and interest soon led to the school district making her computer coordinator in place of her staff development responsibilities.

Rebecca is a gifted writer and talented developer of curriculum materials. She has a deep understanding of education, especially its underlying goals and philosophy. She is very bright, and she works very hard.

Interview

1. *You indicated that the PTA (Parent/Teachers Association) purchased about half of the computers available in your schools. Please tell me more about this, and tell me where the rest of your computers have come from.*

The PTA organization in our city runs a thrift shop that is very profitable. The profits are divided among the schools, using a formula that takes into consideration size of school and the volunteer hours provided by parents from each school. The typical school gets more than $20,000 per year. These funds are allocated by the individual school PTAs for projects of their choice. They have put quite a bit into computer hardware, but it is not evenly distributed among the schools.

Some of our computer equipment has come from research projects we are doing in cooperation with the university. Right now we have a big project underway on use of computers with pre-algebra students. I also have a grant that purchased 30 machines for Logo and word processing at the fifth and sixth grades. This grant was obtained in competition with schools from throughout the state.

At the high school level we have made use of state vocational education funds to purchase equipment. We offer a variety of programming courses and word processing using this equipment.

Surprisingly, our school board has not provided any direct funds for computer hardware. In the past couple of years the board has placed computer education on its top priority list. Unfortunately, each year the budget has been so tight that there was no money available to fund the purchase of hardware. But the board funds my position, so they are making some contribution to computer education.

2. *What aspects of your university training have been most helpful to you in your computer coordinator work?*

   Knowing more than one programming language has been very helpful. My university computer science courses were of very high quality, and I learned Pascal, PL/1 and a little bit of COBOL. I have taught myself BASIC and Logo.

   My university work in curriculum development, learning theory, and program evaluation helped me to get my job and has been very useful. The research courses I took have helped me to get the computer grant we are using to teach Logo and word processing at the fifth and sixth grades.

   The 30 microcomputers we obtained from the state grant are placed in 15-machine labs in two elementary schools. They will be moved to two other schools for the middle part of the year, and to the remaining two elementary school for the last part of the year. We are developing and carefully evaluating materials that can be used by the regular classroom teachers. This is exciting! The teachers receive only two full days of inservice training. We provide them with a computer lab helping teacher, a person who is quite knowledgeable about computers. The computer lab helping person helps to develop lesson plans and makes sure the machines are in good working order. But the teachers have to do the teaching—they are learning by doing, backed up by the computer lab helping person. I think the research training and the curriculum training I received at the university have been excellent in preparing me to handle this computer project. I will probably use it as my doctorate research project.

3. *What are the areas in which you feel your training has been least adequate?*

   My weakest area is in group dynamics, facilitating the functioning of a group. I haven't had any formal training in this area, but I have learned quite a bit by experience.

   I didn't take any math in college, except what was required to be an elementary school teacher. But in high school I was very good at math. I always advise students to take as much math as they can. It keeps doors open.

4. *Please tell me about the planning your district and schools have done.*

   Planning has been given high priority, but not all of our plan has been implemented. For example, we intend to teach keyboarding at the K-1 levels. I have found some materials that I believe will be very good for this. We are not emphasizing computer-assisted instruction. Rather, our long term goal is the integration of computers as a tool throughout the curriculum. I have mentioned the research we are doing with 30 microcomputers in the fifth and sixth grades. The main emphasis is to train the regular classroom teachers to present the instruction and work with the students. Our district plan calls for Logo in grades 3-6, and word processing in the sixth grade. Currently students in these units of instruction are getting three to four hours of computer lab time per week. We have students working in pairs, but that isn't working too well in the word processing. Only one person can type at a time, and it's not very interesting being a typing observer.

At the junior high level, a number of the math teachers have gotten into computing and teach computer math courses. These are under the control of the mathematics departments, but are computer courses. At the high school level, we offer programming in a variety of languages, and we offer word processing. The funds for this are vocational educational money, but the courses are straight computer courses.

Our state legislature recently allocated funds to address the need for computer literacy for students who are near graduation from high school. It is a stopgap measure, designed to catch the students before they graduate. We are working hard to design a plan to use these funds for the purpose for which they are allocated. With student schedules already in place for the year, little software money, and little planning time, we are finding it to be a major challenge.

Our overall district plan calls for an equitable distribution of equipment among the schools. We currently don't have an equitable distribution because so much of the equipment was purchased using PTA funds. But at this stage of development, I question this emphasis on equity. We need to have enough equipment in one place to experiment with new ideas and to evaluate the results. Long-term progress is very dependent upon this research and careful evaluation.

Until now we have not had a formal district policy statement on copying software. I now think I understand the problem both from a teacher and a district point of view. I will work with my Computer Steering Committee to implement a strong policy against stealing software.

Our individual schools do not have computer education plans. However, each school has at least two people involved in computer education. One person, usually a media person, is responsible for software and has hardware maintenance and scheduling responsibilities. They work through my office if a machine needs repair, and they work through my office if their school needs to borrow hardware or software.

A second person from each school is designated as the Computer Steering Committee representative. I meet regularly with this committee. Last year we also had some lay people on this committee, but this year all we have is the one representative from each school.

I am probably the person most knowledgeable about educational computing issues in the district. At the elementary school level, the grant is supporting a full-time computer lab helping teacher who is excellent. At the junior high school level, some of the math teachers spend a good deal of their time teaching programming. They are mainly self-taught in programming. In high school it is the same thing, but it is vocational education teachers who have become the computer teachers.

One of the hardest parts of my job, but a part that I really enjoy, is doing long-range planning. It requires a deep understanding of education—a philosophy of education. It requires a maturity about educational computing that most people don't seem to have. I like to write in this area, and one article I published in *The Computing Teacher* has received considerable attention.

5. *Do you have some sort of support group or other help?*

Within the district I feel somewhat isolated. My contacts with the university are a great help. They have a really good computer science department and school of education. I have close contacts with several computer coordinators from other districts, where our jobs are similar. We get together regularly at conferences. Our state has an computer coordinator, a media person. This person works hard to provide opportunities for us to learn from each other. The state provides us with hardware help via a state purchasing contract.

6. *How many hours per week do you work?*

I work about 60 hours a week. I guess I do about 20 hours a week on my program evaluation duties and the rest in the computer field. I spend most evenings reading computer materials. I suppose I spend about 12 hours a week trying to keep up in the computer field. There is so much to read, and I am not a fast reader. Also, I really enjoy writing. I spend quite a bit of time writing articles and software reviews, and I am working on a book.

7. *What are the most exciting and least exciting parts of your job? Do you have a pet peeve?*

The most exciting is writing, giving talks, working with individual teachers, and seeing teachers get excited. I really enjoy staff development work.

One thing that we did last year was very exciting. We had a family computer fair day that drew about 1,200 people. The emphasis was upon family computing, families sharing the computing experience. We had about 30 families bring in their machines and discuss home uses. We now offer family computing courses in the evening. One going on now is being team taught by an adult and a junior high school student.

The least enjoyable part of my job is anything related to administrative computing or to administrative work. I don't like to keep track of our machines, do scheduling, worry about budgets and so on. Until recently I was often called upon to help with administrative computing in the district. Now the district has hired a person to take care of that.

My pet peeve is people who are opposed to computers who have not taken the time to try to understand them.

8. *What else would you like to tell prospective computer coordinators?*

Keep the school rabbits away from the computers. If they escape from their cages, they will devour expensive power cords. I wish I'd been advised about this before I became computer coordinator!

Be prepared to be overwhelmed by the job, and be prepared to work very hard. Don't expect anyone else in your school system to really understand what your job involves. The program development aspects of instructional computing, developing a K-12 plan, are difficult. But being a computer coordinator is exciting. For me, it is by far the most interesting and rewarding work I have ever done!

Follow-up Interview

Rebecca has continued to grow quite rapidly in her professional capabilities. She has participated whole heartedly in the computers-in-education revolution. Here are her responses to five questions.

1. *Can you share some of the changes that have occurred in your life and job during the past six years?*

Many changes have occurred in both my personal and professional life over the past six years. In 1984 I was juggling diverse roles, with all of them needing "top priority" status. These roles included wife, mother of two young adolescents, doctoral student, and full-time coordinator in my school district. Now, the roles are fewer. I completed my technology-based dissertation and received my doctorate the year our older child graduated from high school. This year, with both children away at distant universities, responsibilities certainly seem more focused.

Although my job title remains basically unchanged, how I spend my time and my view of my work are dramatically different. The changes have as much to do with my own development as they have to do with actual changes that have taken place in my district or in the world of instructional technology, although those changes and my development are inextricably intertwined. Much of what I believe to be true about technology, education, and change has evolved as a result of my observations, experiences, and study over the past six years.

Six years ago I thought moving a school district to high quality use of technology would be much easier and quicker to accomplish than I now believe to be the case. In 1984, my definition of "high quality use of technology" was also much less complex than my vision in 1990. My focus in 1984 was on getting more hardware and software into the district, and on training teachers how to use it. The focus was squarely on the technology. Success would be measured in terms of quantity—numbers of computers and numbers of teachers who used them.

My focus in the 1990s is on what impact I can have in moving my school district in the direction of offering an education that is appropriate for the Information Age. Whereas I used to see myself as a technology specialist, I now see a much broader role. I'm involved in issues relating to testing, site-based management, interdisciplinary instruction, and curriculum that develops problem-solving strategies. I justify my involvement in these areas because I believe that the current structure of our schools puts many roadblocks in the paths of teachers who want to implement the most exciting and educationally valid uses of technology.

Our reliance on norm-referenced standardized tests as a primary form of assessment puts a roadblock in the path of teachers who want to foster critical thinking through the development and use of databases in social studies. It is a roadblock to teachers who want students to engage in problem-solving through the reflective exploration of Logo microworlds.

Dividing our school day into 55 minute chunks of content-labeled time puts a roadblock in the path of teachers who want their students to use technology as a production tool for interdisciplinary projects, to teachers who want to have students work intensively on a collaborative writing project, and to teachers who want to use microcomputer-based labs to foster an inquiry-based approach to science.

Giving teachers a 10-month contract puts a roadblock in the path of teachers who need sufficient time to learn and think in order to use technology well and to teachers who need extensive planning time to develop their interdisciplinary lessons with their team-mates.

Organizing schools so teachers don't have any significant periods of time away from instructional and routine duties puts a roadblock in the path of teachers who wish to coach their colleagues in the use of technology. Structuring schools so each teacher teaches 150 students each day puts a roadblock in the path of teachers who want to spend adequate time with small groups of students as they use a variety of media to develop their desktop presentations.

So, to be a successful instructional technology coordinator, I need to be a strong advocate for school restructuring. As a result of this thinking, I now put much of my time and creative energy into issues relating to school restructuring.

2. *What changes for the better have you seen in instructional use of computers and related facilities in the past six years?*

   In 1984 we were thinking about how to make the kids computer literate with two or three computers in our schools. We had patched together some rotating labs that remained in schools for a few months. With so little hardware, computer experiences were few in number.

   Now, we have labs in each school. In most schools, the labs are housed in facilities specifically designed for that purpose. In addition to the labs, most classrooms have at least one computer. Computers are used extensively as tools for word processing, and computer-assisted learning takes place at all grade levels. We've dabbled with other forms of technology through an Emerging Technologies Grants program that I've instituted in our district. As a result, we have teachers including telecommunications and laser disc projects as part of their instructional programs.

3. *What changes for the worse, or lack of progress, have you seen in the past six years?*

   We should not (must not) focus on lack of progress. Instead we must focus of the progress we *have* made while keeping in mind the distance we still have to go.

   In my own district, I believe that we have come about as far as we can come without implementing some of the significant changes I discussed earlier. I am very hopeful that the site-based management model we will be implementing in the fall will give greater flexibility to schools to use existing resources in more meaningful ways and that the model will also get teachers and parents more involved in making important decisions concerning the educational program. We will also have some additional resources available to schools to be used for staff differentiation. Hopefully some of these additional resources will be used to further develop the quality of technology use in our school district—but for the purpose of achieving the broader goal of better matching our educational program to the world our children will enter when they leave.

4. *What do you see happening in the future?*

   I believe we will see major changes in schooling in the years ahead. There are so many indications that our schools are not adequately preparing our students for the 21st century (nor, even, the 20th century!). It is up to us as educators to bring about change. It is up to us who are instructional technology specialists and have interacted with cutting-edge technologies to involve ourselves in making change happen. If we do not implement change from within education, it will be legislated by non-educators.

5. *What words of advice do you have for a person who is now thinking about becoming a Technology Coordinator?*

   Do it! You will work harder than you ever imagined, be frustrated, be overwhelmed, be pulled in a million directions, and be fighting an uphill battle. BUT you will also be involved in work that can make a real difference in the way teachers teach and students learn.

   Don't try to do it alone. Remember that real change only takes place when the people who are to implement the change believe that it is important. Invest in people first, hardware second.

   Spend at least half of your time involved in broader issues than the nitty-gritty day-to-day aspects of the job (this is hard to do, but absolutely essential for success!)

Have fun! Allow silliness! Don't take this awesome responsibility too seriously! It takes a long time to gain real perspective about school change, and you can't make a real contribution if you're burned out.

Analysis

Rebecca exudes optimism about the underlying potentials of computer-related technology to facilitate great improvements in our educational system. She has the breadth and depth of knowledge that can lead a school district in restructuring. This knowledge is far more than knowledge of just technology. It is knowledge of the overall structure of our educational system and the roadblocks it places in the way of any changes.

Perhaps the key message is that substantial restructuring is needed to bring our schools into the Information Age. No amount of technology, by itself, will accomplish this aim. A good TC with talent and vision can move a school district on a steady path to substantially improving the quality of education being received by students.

Urban County Computer Coordinator Interview

Position Description

Edward is an instructional computing coordinator for a large, heavily populated county district that includes nearly 25 school districts, 140 schools, and 70,000 students. His job is to promote progress in effective instructional use of computers throughout all of these school districts. Details of his job description vary from year to year, but always involve being up to date and knowledgeable in all aspects of instructional computing. He serves as a hardware, software, and planning consultant to the school districts in his county. He is working on a cadre leadership program, identifying one person in each school; coordination of staff development is one of his responsibilities. He works with and fosters local computer-using educator groups. Part of his job is to be active at the state and national level in professional computer education groups. Finally, he must also act as a public relations person for computer education activities in his county. Edward has secretarial help, but does not have a staff of computer people working under him.

Qualifications

Edward is a state and national leader in computer education. He is a well-known author, consultant, speaker and planner. He has worked as an educator for about 20 years, initially as a business teacher and then in computing.

Edward began using computers in the classroom in 1967, and he taught computer programming for many years. He is a very bright, hard-working and dedicated educator. He was one of the first people to serve as a computer coordinator in his state. In this interview he presents a number of important ideas acquired through his many years of involvement as a computer coordinator and instructional computing leader.

Interview

1. *What do you feel are the most important aspects of your preparation that have helped you to become a successful computer coordinator?*

   I don't believe that there was anything specific in my college training that has been particularly important to being a computer coordinator. Most valuable to me has been the problem-solving, group facilitation, and human relations skills that I have obtained by training and experience outside of the formal university environment. My computer knowledge is self-taught.

   In a non-training environment, what has been most important is that I am a voracious reader. I regularly keep up with about 25 periodicals, and I scan the table of contents of another 25 periodicals. If people are interested in this type of job, it is imperative that they keep up to date, and the only way to keep up to date is to read. If you are not a heavy reader, I suggest that you seek some other occupation. It is also helpful to attend conferences and to talk to knowledgeable people from throughout the country. But reading is the key.

2. *What are some of the most important things you do?*

   I work to develop leaders, people who can help accomplish my job responsibilities. I do this by developing a cadre of leaders, of people who can be computer coordinators at the school and district level. I help these leaders develop their skills as teachers of teachers, as leaders in local and regional computer-using educator groups, as writers, and so on.

This task can be frustrating, since quite a bit of their learning and growing processes must be experiential. They keep trying to reinvent the wheel, making the same dumb mistakes we made years ago. I try not to stifle their initiative, but I do get frustrated. I encourage them to do more reading so they can be better aware of what others have already done and/or are doing.

3. *Where is the computer education field headed?*

I expect the number of computers available to students to grow rapidly. I believe that where we are headed is not a focus on computer literacy or computer programming. Rather, it is full integration of computers into the curriculum, making use of applications software. Many leaders now understand this, and we are doing a much better job of working toward this type of integration.

Another good thing that is going on is that the individual school districts are beginning to develop long-range plans for instructional use of computers. This has been surprisingly slow to happen. The funds coming from our state legislature are requiring this type of planning, and I feel such planning is an absolute must. I work with the district personnel, with parent groups, with computer-using educator groups and with others to develop these plans.

This suggests a major duty of computer coordinators, something I really enjoy doing. A computer coordinator must collect, consolidate, and share information on what other school districts have done. This is so that individual school districts and schools don't have to reinvent the wheel as they do their planning and implementation.

4. *How do you or your districts evaluate progress in instructional use of computers?*

I don't think anybody does; that's part of the problem. Even the state funding we are receiving does not require any careful evaluation. Anecdotal comments are all that are required. That is terrible.

5. *What are some of the least fun parts of your job, and what is your pet peeve?*

I don't like to field questions from people elsewhere in the country when they have their own local or regional computer coordinators. People will call me or visit me, and expect me to answer all their questions. I don't have enough time to do my own job, much less the job of people living on the other side of the country.

I don't like to deal with the petty politics that go on in a county education office and in the district offices. I don't like to deal with questions that really belong to our administrative computing people. I don't like to get involved with any aspects of administrative applications of computers, but I get stuck with quite a bit of this. I am intolerant of people who are supposed to be technically competent, and who aren't.

I am not too happy with my lack of job security as a computer coordinator. No matter how well I do my job, my boss or the superintendent could make my job disappear. Several of us who hold similar computer coordinator positions get together occasionally to discuss problems of mutual interest. We have discussed our job situations and find it to be scary. I find it quite helpful to get together with this group of computer coordinators, and I wish we could arrange to do it more regularly.

My pet peeve is that people expect me to give them an answer. They ask a specific question, such as "What piece of software should I buy?" I want to give them options and have them learn to make their own decisions.

6. *What are the most critical decisions you have to make as a computer coordinator?*

I make recommendations on hardware and software. I find it difficult to maintain an unbiased and open-minded position. People come to me and they want specific answers. "What piece of hardware should I buy?" I work hard to present them with alternatives and to help them to make reasonable decisions on their own. It is easier with software, to say that this particular piece of software is better than some other piece of software. In both areas I feel I am under a lot of pressure, but I try to pass the pressure on to the people who are actually doing the purchasing and will have to live with the decision.

7. *What do you feel are the most important qualifications necessary to do your job?*

I do not feel technical expertise is anywhere nearly as necessary as human skills—human relations skills and curriculum knowledge. I might have said something completely different in the past, but my feeling at this moment is that my knowledge of computer uses in the classroom is far more important than my ability to write good programs in several languages. It is also very important to know where/how to find information and to be good at brokering resources. Group facilitation skills are essential. Being able to listen to people, to find out what they are really saying, is very important.

8. *Several times in this interview you have mentioned job-related stress. Could you expand on this?*

As I have indicated, my job involves working with many different people and responding to their needs in the areas of hardware, software planning, and inservice education. And, my job involves keeping up. If I spent all of my time reading and talking to knowledgeable people from throughout the country, I would still not keep up as well as I would like. If I spent all of my time working with the people in my districts, I wouldn't be able to do all that needs to be done. Thus, I am continually under stress, trying to accomplish two tasks that are each more than I can do to my satisfaction. Sometimes I take out my frustrations on the people I work with. Sometimes I am impatient, not able to really listen to where they are coming from and to understand their point of view. I need to learn to calm myself down.

I really like my job; it is exciting, and I feel that I am making a major contribution to education and our society. But sometimes I think about taking early retirement, spending my time doing just what I want to do.

9. *What else would you like to share with us?*

I would tell people who are thinking of becoming a computer coordinator to make sure they understand a lot about curriculum. Make sure they understand what their objectives and motives are in taking a job like this. It should be to help everybody and to share their knowledge, not to keep the knowledge to themselves. This is really important. Some computer coordinators seem to think of their knowledge as power, and they try to use it to establish a power base. They act like they want to share, but in reality they are on a power binge. They do not seem to be dedicated to improving the educational system and helping kids. You have got to have the notion of sharing.

My own attitude about my job is that one of my responsibilities is trying to work my way out of my job. I try to develop district computer coordinators and school computer coordinators who can do what I am doing. If I do it well enough, I won't have a job. I am a sharer; I believe in sharing. I feel that is really important.

Follow-up Interview

Edward has continued in has role as a national leader in the field of computer-related technology in education. He has contributed significantly to shaping the changes that this technology is bringing to education.

To a large extent, it is from his insistence that the title of this book changed from *The Computer Coordinator* to *The Technology Coordinator.* The interview with Edward was done via his responding in writing to five questions. He prefaced his responses with the following:

I'd like the questions and your article to reflect one big change that is only alluded to by the wording of the questions—we now must think of technology as meaning *all* technologies, not just computers.

1. *Can you share some of the changes that have occurred in your life and job during the past six years?*

   I have a new job—I am now the Director of Media Services, which is mainly film and video, but with my background, I am expected to make the job into a Director of Technology. The expectations people have of what I know and know well has simply added film/video and ITV to the already-long list. I am the fourth computer-technology person in this state to step into a position like this, and I expect that we will see many people doing the same thing. After all, the technologies really are merging, aren't they?

   Before I left my Technology Coordinator position, I found myself working much more closely with curriculum people, trying to enlighten them about the uses of technology to help teach the subject matter and beseeching them to include technology in all of their staff development activities. It is absolutely essential that we are successful working with these people, but it ain't easy! It some cases, the cooperation was amazing and the results excellent. With others, I still have a lot of work to do.

   I also find myself working more with the state department of education on committees, special projects, etc. This, too, is essential activity (though frequently v-e-r-y frustrating) as the state does provide leadership in many ways. That leadership can be negative when leaders are not well-informed—witness the situation that California's State Superintendent Honig created when he came out so strongly in opposition to Channel One.

2. *What changes for the better have you seen in instructional use of computers and related facilities in the past six years?*

   Contrary to what the nay sayers say, I think instructional software has improved by leaps and bounds and I wish people would quit saying there isn't any good software out there. There are still companies producing junk, and that won't change. But the companies in the educational software business for the long haul are producing some very creative products and should be commended for their efforts.

   I'm encouraged by the emergence (finally) of videodisc technology and the new technologies that were developed to support it in the classroom. Hypermedia software and tools such as bar-code readers will make this technology far more usable by non-techie teachers. Again, some producers have not improved the quality of their products by placing them on the videodisc medium, but those that have made the investment to take advantage of what the medium has to offer have been producing excellent materials.

   I am encouraged by the redirection of attention towards providing a workstation for each teacher's desktop and pleased to see that leadership is coming from the NEA. In the "lessons-we-have-learned" category, I like to think this is one we finally figured out, despite the fact that it took 10 years or more to do so.

3. *What changes for the worse, or lack of progress, have you seen in the past six years?*

   First on the list is the lack of reliable, repeatable, research that shows that educational technology improves or enhances the learning of kids. The bubble will burst soon if we don't start demonstrating that what we are doing works.

   I'm disappointed, at least in my state, at the lack of recognition for site-based technology coordinators. Most people who rise to the occasion do so on their own time, at their own expense. That's no way to build a support infrastructure and a support infrastructure is what we need, desperately.

While some school districts have developed marvelous Technology Plans that they follow religiously, many more have wonderful "paper plans" that are only used to justify requests for special funding or are quoted from when writing grant proposals. The process of developing a Technology Plan is a valuable one, but to not provide funds to implement it makes the whole process a waste.

4. *What do you see happening in the future?*

   The anticipated retirement of many "senior" teachers will hurt the educational technology business. Contrary to opinions of some, new teachers do not use technology as soon as they bounce out of college. It takes years for them to learn the craft of being a teacher and by the time they do, they may have neither the time nor the inclination to use technology. Most technology-using teachers have between 15-20 years of classroom experience. They represent the leadership in this field, and many are approaching retirement age. Where will our future leadership come from? Look at all the gray hair at the next NECC conference!

   The future will bring the adoption of technology materials by the textbook-adoption states (easy to predict since Texas has already done it) that will influence textbook and technology purchases in all the states.

   The growth of the Integrated Instructional Systems (I can't bring myself to calling them ILSs) bears watching. As IIS companies change from selling drill-and-practice materials to selling "multiple-media teaching systems," their products will replace textbooks and other media (at *very* high prices). It will be fascinating to see if the IIS companies can make the transition and will be successful.

   Regardless, those of us with ants-in-our-pants have been disappointed at how s-l-o-w the change process proceeds, and one safe prediction is that s-l-o-w will not change.

5. *What words of advice do you have for a person who is now thinking about becoming an Instructional Systems Technology Facilitator?*

   Reconsider what you are doing—the classroom is a much happier place to be, especially if you like being your own boss!

   Make sure you are ready for your new assignment.

   - Ready does *not* mean you are a techno-guru
   - Ready means you think (and know) technology, not just computers.
   - Ready means you understand curriculum reform and what is going on around you.
   - Ready means you are willing to participate in collaborative problem-solving and decision-making.
   - Ready means you are willing to put your ego on hold while you put up with what can only be called administrivia, including lots of boring meetings.
   - Ready means you've learned about purchasing, buying, and budgeting procedures in your district—things "other people" did for you for the last few years.
   - Ready means you understand the concept of time management but are willing to laugh about it.
   - Ready means you have developed a marvelous sense of humor that nothing can dissuade!

   While you're at it, be prepared to *insist* on a job description that will guide what your responsibilities are and include those things that you are NOT responsible for.

And finally, develop the attitude that your primary task is leadership development—developing the skills of other people so they can take over the things you are doing now—so that you can move on to the next emerging technology, whatever that might be.

Analysis

Few people have Edward's insights into our educational system and the overall field of technology in education. His "I calls them the way I sees them" attitude is always refreshing and insightful.

Edward displays a relatively high level of skepticism about the claims being made by people who produce and distribute technology-related instructional materials. He has been in education long enough to have witnessed the coming and going of a large number of such products and the companies producing these products. Still, he remains optimistic about the future of technology in education.

Small High School Technology Coordinator Interview

As part of the process of updating *The Computer Coordinator* book, I interviewed a person I have known for many years and who has been a technology coordinator in a small high school for a very long time. The interview format was similar to that used in the 1984 interviews.

Position Description

Mark is a TC in a 525-student secondary school (grades 7-12) located in a town with a population of about 9,000. He carries a full teaching load of computer programming, computer applications, math, and other courses. He has substantial responsibility for the computer hardware and software facilities in the building, for staff development, and for planning. However, he does not receive release time or extra pay for this.

In his position as a school TC, Mark controls a budget of about $10,000 and is responsible for the majority of the instructional computing-related activity in the building. He coordinates the planning done by the teachers who make most heavy use of the computer facilities. He provides the leadership and vision as the school works to deal with multimedia and hypermedia.

Qualifications

Mark has had a great deal of formal education, including a master's degree in mathematics education, approximately the equivalent of a master's degree in computer education, and completion of the minimum requirements for an administrators certificate.

Mark has worked as a math teacher, as a district math coordinator, as a computer teacher, and in his current position. His educational involvement with computers goes back to the early 1970s. He has had nearly 25 years of experience at the secondary school level.

Interview

1. *You have been involved with computers in schools for nearly 20 years. How did you get started, and how do you keep up with the changes?*

My school was involved in a federally funded computer education project during the late 1960s, but I wasn't involved with that project. When I started to work in the school, the project had ended and the computer facilities were largely unused. I attended a National Science Foundation Summer Institute in computing in 1973, and another one in the summer of 1974. With this background, I was able to make effective use of the minicomputer and the time-shared computer facilities that were available in my school and school district.

I was a math teacher, and it seemed both natural and appropriate to integrate some computer programming and computer use into the math classes I taught. Later, I developed computer programming courses.

From quite early on, I realized that there is a lot to learn about computers and that the field is changing quite rapidly. When I had a sabbatical leave, I spent it studying computers in education. I have attended a number of computer education workshops and I regularly attend computer education conferences. I spend quite a bit of time each week reading computer magazines and playing with new pieces of software. I find *The Computing Teacher* (published by ISTE) to be probably the finest source of information relating to practical, realistic use of computers in education.

2. *What do you consider to be the most import qualifications necessary to do you job well?*

   I feel that the most important qualifications are to be technologically knowledgeable, to be able to work with people, to have the best interests of the whole school in mind. You cannot teach that which you don't know. You have to be able to do what you suggest to others. You have to keep in mind the "big" picture but at the same time be highly conscious of details. You have to be part administrator, part teacher, part teacher trainer, part computer expert, and be dedicated.

3. *What is your school doing with computers?.*

   My school seems to do computer things in spurts and plunges, often with a few years of ignoring computers preceding each upward step. Over the years, my school has achieved a computer ratio of about one machine per eight students. We have four computer labs. Money for the hardware came from the district, from special programs, from fund raising, and from within the school.

   The school district has provided some staff development and quite a bit of encouragement. It provides repair services. However, the district does not have enough funds to provide the level of computer facilities I feel are needed in a school. None of the other schools in the district have been able to achieve as good a student-to-computer ratio as we have.

   Of our 30 teachers, about a fourth are regular and knowledgeable computer users, and another 40% are reasonably comfortable in dealing with a word processor.

4. *How do you and others evaluate computer-oriented progress in your school or school district? Is there an evaluation plan for the district or for individual schools?*

   There is no formal evaluation of computer use in our district. At the building level I evaluate how we are progressing, but not in a very formal manner.

   I am in the process of establishing a statistic that should help in evaluating a school's computer/technology use. First, count the number of computers in the building but exclude those in the staff work room, main administrative office, and in the counseling center. Then multiply the number of computers by the number of periods scheduled each regular day. (We have 83 computers. Multiply by 7, the periods in a day. Result is 581.) Multiply this product by the number of student contact days in a standard school year less 20. This is on the assumption there is minimal use by students the first two weeks and the last two weeks of the year. (At my school, this is approximately 150 days. Thus, 581 times 150 equals 87,150.) This is the number of potential student contact periods (or hours, since most periods are about an hour long).

   It is necessary to keep track of actual use of each computer and log the times. This is not as difficult as it seems, since many of the computers are used by a class of students every day. Our technology center assistant keeps the daily count on a chart. At the end of the year, just compute how much time on the computer actually occurred. I define "good" use of facilities at about 67%. In the 40%-66% could be classified as moderate use. Anything less that 40% indicates to me that the school should reexamine its facilities use. Our goal should be to use the equipment about 80%.

5. *Does your school have a long-range plan for use of instructional systems technology?*

   Yes, we have a plan. Here is a brief summary.

   1. All students are able to use the computer as a tool for:
      a. Written communication (word processing).

   b. Data acquisition, manipulation, and display (databases and telecommunications).

2. All students are able to use modern technology to augment their learning. (simulations, drills, and tutorials on the computer, use of the video tape recorder, video disc player, and test scanners).
3. All students are computer literate.
4. Students have the opportunity to learn advanced skills involving the use of computers, such as:
   a. Computer programming (BASIC , Pascal, *HyperTalk).*
   b. Advanced applications relating to business.
   c. Advanced applications, general.
   d. Computer graphics.
5. The staff uses the computer to increase the effectiveness of their instruction where appropriate; for example:
   a. Use the computer to display information or processes.
   b. Use the computer to manage instruction (grade books, inventory, etc.)
   c. Use the computer to create handouts, tests, and other items involved in instruction (word processing, graphics, puzzle makers, test makers, etc.)
   d. Use the computer for data analysis (test scanner, data bases, spreadsheets, statistical packages).
   e. Use the editing power of word processors to assist in the teaching of writing.

This year in our school, all teachers were required to have a personal educational goal for their courses that included the use of computers. For example, many of the Language Arts (English) teachers wrote that they would have their students prepare at least one essay using a word processor.

6. *How are you evaluated? What do you do to maintain and increase your competence as a tech facilitator?*

I am evaluated by my principal and he is my direct supervisor. Being in a rather remote area of the state, there are no local resources to further my education. I am on my own. I study, read, and listen to keep myself abreast of what is happening nationally and within the state. Occasionally I get to go to a conference to get new ideas and information. I spend about 10 hours a week just learning. Most of this is through experimentation and practice using software. Lots of reading of periodicals—seldom books.

7. *What are you proudest about, in terms of your TC work?*

Two things. First, my school is close to 100% legal. Our high school has a policy regarding the copying of disks. We make an effort to prohibit and discourage the illegal copying of disks by both students and teachers. Although almost impossible to eliminate entirely, I think we have done a fair job on eliminating piracy within the school. We have purchased site license and multiple copies of software used by many students or classroom groups. The building administration supports this policy.

Interestingly, the administration and staff throughout the district are not too thorough about following this policy; they seem to think they are exempt from the copyright laws or feign ignorance.

Our position regarding illegal copying is that the staff must set a good example for correct behavior, regardless of how they personally feel about it. I take the position, "What you do outside the school is your own business, but as a teacher you do not violate a law even if you don't agree with it."

Second, although we are a small school and the overall level of education in our town isn't very high, we are doing well in the computer field. Our students have good opportunity to learn to make use of computers. I think we are keeping up with many of the so called "better" schools in richer schools districts.

8. *Do you have a pet peeve about your TC work.*

Yes, I have several. One is school administrators who don't know much about the computer technology, but try to act like they know a lot. They happen to have an intimate knowledge of usually one brand of computer and a few software applications that they personally use, but they seem to be missing the "big picture." Often they seem to be more interested in getting what sounds good for them to use or other equally "knowledgeable" staff. They ignore what is best for all students. They don't recognize the fact that modern technology affects the whole curriculum and all students, not just a few academically talented business or computer oriented students. They are more concerned about having one sophisticated, complicated new system than providing computer facilities for the whole school.

My second peeve is our very slow progress toward the goal that I am sure is correct. There seems to be two major problems involving the use of the new technologies in education. One problem is the lack of integration of the new instructional technologies into/with the traditional curriculum. The second problem is that the schools have not changed the curriculum in light of changes in business, industry, higher education, science, and the world in general.

9. *I am really impressed by the overall plan that your school seems to be following in making effective use of computer technology. What is the underlying theme you have followed?*

I think the underlying theme is the importance of computer literacy, especially word processing and information access, for *all students and all teachers*. This is often overlooked by people planning and operating computer facilities. Computer technology is for everybody. Not just those kids interested in business courses. Not just those who want to study computer programming. Not just the computer teacher. Or the business teacher. Or the math teacher. *All!*

This reference to *all* often gets lost in teacher and administrator planning. More effort seems to be in "empire building" within the schools or "feathering ones own nest" in acquiring equipment and software. The needs of the few are overlooked by those responsible for planning for all. Departmental and interschool rivalry and teacher favoritism seem to take precedence over the central purpose of public education. I often see individual teachers or small programs desiring and acquiring new facilities and resources which only have an impact on a few students or teachers, while the majority of the students and staff are ignored.

To top it off, these people rationalize this type of behavior, saying that they are just supporting those who want to use computers. Or, they say that it is important that we provide high-level technology for those who are ready or need it. This is often advanced courses in the business or computer department; or, it is designed to provide more facilities for those teachers who already are using computers. This type of thought absolves them of the responsibilities for the whole staff or the whole student population. Also, it is an easy way to avoid the much more difficult task of teaching all.

10. *What else would you like to tell people who are thinking about becoming a TC?*

Always keep in contact with the classroom. Teach at least one class that relates to your experience and technology. Too often, the district TC forgets what it is really like in the classroom. Lack of classroom experience on a regular basis leads to a lack of attention to detail and one quickly forgets what teaching is all about. The lack of contact also leads to an attitude towards teachers that can be counter productive. As a regular classroom teacher, even if only one hour per day, you become part of the teaching staff and this makes it much easier to work with the staff. In many buildings the outside expert who is not a teacher does not enjoy the respect of the teachers "in the trenches."

Keep in mind that technology is not a cure-all to the many problems facing education today. There are many other high-priority projects within the schools. In fact, many of the problems faced were caused by modern technology (loss of traditional jobs, added paperwork, the necessity of revising the curriculum, etc.). Don't be over enthusiastic—this turns off many teachers, especially those who are technophobic. Start with reasonable small applications within the classroom. You may have to demonstrate how effective the computer can be. Be sure to involve the teacher at every step. Don't get trapped into a demonstration where the teacher becomes just an observer—keep the teachers involved. Stay with the demonstration from beginning to end—don't assume the teacher will finish up the unit. Stay with the teacher when they try their first computer application with their class. Support them.

Don't get carried away with all the new high tech facilities. Seldom does a school need all the new devices that real power users need. You'll see many schools spending tremendous resources to support just a few students or staff. You are responsible for all staff and all students. For example, it may be better to acquire five Apple GS units and one shared printer than a new Mac II, hard drive, printer, color monitor, CD-ROM reader and related software.

Be sure to acquire software that is usable for classrooms. Don't invest a lot of money on single copies of many titles. Make use of the published software reviews. Get the best—and then get it for everyone who will use it, or be sure to have enough for the whole lab. Site licenses, network licenses, and lab packs are the best way to acquire good software.

Appendix A

Twenty Years Ago

Author's Note: This editorial written by David Moursund was first published in the October 1983 issue of The Computing Teacher. It provides an historical perspective of the field of computers in education.

I have begun two of my recent talks by discussing what computers in education was like about 20 years ago. This was easy to do because my first serious involvement with computers in education occurred in the summer of 1963. I had finished my doctorate six months earlier and was spending part of the summer in helping to teach some bright high school students a little about computer-related mathematics.

By 1963 the computer industry was well into the second generation of hardware. Transistorized computers with core memory were widely available in universities and large colleges. ALGOL, COBOL and FORTRAN had made their debuts, as had fairly sophisticated batch processing systems and the initial time-shared systems. BASIC was under development at Dartmouth.

The university I was attending graduated its first Ph.D. in computer science in 1963, although they didn't call it by that name. Quite a few computer science departments existed by then, but some universities resisted their establishment more than others.

The profession of computer science was well established. Indeed, the Association for Computing Machinery (ACM) had been in existence since 1947 and was growing rapidly. In the 1960s the ACM took a substantial interest in college-level computers in education. The "Curriculum '68" report contributed substantially to defining an appropriate undergraduate computer science curriculum.

Computer assisted instruction was well established by 1963. While there were many small projects, perhaps most interesting historically is the PLATO project that began at the University of Illinois in 1959. By 1963 this project was well underway and beginning to receive national attention.

Computers were already in some precollege education systems and the teacher education problem was already being attacked. Richard Andree of the University of Oklahoma was active in teacher education and publishing articles about computers in precollege education by 1958. (I'm sure there were other pioneers in the late '50s or even earlier. I just happen to know Richard Andree and have seen some of his early papers.)

This type of historical perspective is fun, and it can also be useful. Suppose that you were magically transported back in time to the year 1963 with your current knowledge of computers and education. What type of advice and leadership might you have provided to the emerging field of computers in precollege education? That is, what should we have started doing in 1963 to help computers in education today?

One can examine various aspects of computers in education to come up with ideas. For example, consider hardware. It was already evident in 1963 that hardware would continue to improve rapidly, with substantial decreases in price-to-performance ratio and continued improvements in reliability. Your 1983 knowledge probably would have made little difference.

Or, consider software. Perhaps you could have hastened the development of Pascal or Logo. You could have helped broaden people's perspective about programming languages. You might have caused the expression “user-friendly software” to come into earlier usage. But to a large extent the software field was moving as fast as it could.

However, the mention of Logo is an important idea. Few people in 1963 imagined that eventually we would have a language especially designed for young students and that computers would become a useful tool in the elementary school. Consequently, few people did appropriate underlying research and development.

A government agency could have funded several K-12 experimental computers in education schools. Work in understanding what computer-related ideas were most appropriately taught at the different grade levels and how to integrate computer-related ideas throughout the curriculum could have been studied. Development of an entire K-12 curriculum that assumed easy computer access for all students could have begun.

Certainly the results from such experimental work would be valuable today. And this suggests another important idea. Who are the leaders of computers in precollege education today? Many are people who were beginning their careers 20 or more years ago. Could we have done something to help develop more of these leaders? Certainly!

But what does all this have to do with today? I think the answer is obvious. Over the next 20 years we will continue to make very rapid hardware and software progress. Computers will become available to all students on an easy access, everyday basis. But, where are we headed? Who is doing the needed research? Where are the experimental schools? Where are the curriculum development projects? Are we producing enough potential leaders?

The United States government and governments in a number of other countries are concerned with the current quality of education. They are especially concerned with technology and with computers. What should they be doing? I feel that the previous paragraph provides one answer. Look to the future and make some long term investments. Fund the research, the curriculum development, the leadership development. This type of funding is essential to orderly and high quality progress in the field of computers in precollege education.

Appendix B

Historical Look at the Future

Author's Note: This Appendix is Chapter 12: Asking the Most Important Question, from The Computer Coordinator *published in February 1985. The chapter focused on the near term future of the field of computers in education. In retrospect, it proved to be a relatively accurate projection of the five-year future. Generally speaking, it is possible to make relatively accurate forecasts of the hardware that will be available in five years. This is because it takes about five years for "state of the art" hardware that the research labs are just announcing, to reach the mass markets. Software progress is somewhat more difficult to forecast.*

Chapter 12. Asking the Most Important Question

Author's Note: This chapter provides me with strong personal evidence on the power of word processing. It began life during fall of 1983 as a perspective editorial for The Computing Teacher. *However, it didn't get used for that purpose. Later it was greatly expanded and modified into a keynote address for a 1984 spring computer conference in Alaska. Later some of its ideas formed the basis for a keynote address at a summer 1984 computer conference in Oregon. Now it has been revised and expanded to become a book chapter. This chapter contains ideas important to computer education leaders—especially to computer coordinators.*

The field of computers in education is beginning to mature. In a number of states and provinces there are now enough microcomputers and enough computer-literate teachers so that we can move beyond the initial exploratory stages of instructional computer usage. But most people have trouble seeing where we might be headed. They fail to ask the right questions, and they fail to set the most significant goals. The overall goal is to improve the quality of our educational system. The question to ask about each potential computer application is how it contributes to the goal. One of the main groups of people that should be asking this question is computer coordinators. It is their job to provide leadership as computer usage continues to grow and to have a significant impact on our educational system.

Over the past 10 years I have traveled extensively, giving keynote addresses and workshops at innumerable conferences. I have served on a variety of regional and national committees exploring issues of computer literacy and goals for computer education and teacher education. I have talked extensively with hundreds of leaders in computer education.

This intense involvement has given me the opportunity to monitor the progress of instructional use of computers. From my perspective, the progress has been relatively slow, but steady. The goals that most school districts are now setting and planning to implement were articulated 10 years ago or more. The necessary types and depth of teacher training seemed clear even then. (A list of the goals is given in Chapter 2.)

However, three major changes have occurred over the past decade. Microcomputers became available, decreased in price, and increased in quality, making it feasible for schools to have appropriate computer equipment for computers to begin to have a significant instructional impact. Software intended for use in education or suitable for this use has proliferated; it is now rapidly increasing in quality. And equally important, a great many educators and lay people have become convinced of the educational values of computers, and therefore are lending support to setting and implementing instructional computing goals.

It has been fun to watch the changes during the past decade and to sense their acceleration toward ever-higher levels. People in the computer field are used to change—indeed, they seem to thrive on such change. Major changes in hardware and software are occurring, and the passage of even one year allows us to clearly identify the trends. Hardware continues to become both more capable and less expensive. The 16K system with a tape drive has given way to 48K or 64K systems with a disk drive. Some school systems are now specifying 128K as minimal requirements for the new systems they purchase. Printers are more common, as are color monitors. A trend toward graphics pad, touch screen, or mouse as input devices is now evident.

A year ago it was still common to hear, "Ninety-five percent of the educational software is poor or worse." Now the figure quoted is often eighty percent, and the eighty percent is of a larger base. Certainly there is a clear trend of more and better software. This trend is especially evident in applications software and in integrated packages of this software. Integrated packages are now being tailored to the needs of education, and that trend will continue.

It is relatively easy to predict the short-term (five-year) future of the relatively inexpensive microcomputer hardware systems most apt to be available to schools. One need only look at microcomputer hardware components that are now in mass production or just about to enter mass production. The 16-bit CPU chip is in mass production and several companies are producing 32-bit CPU chips. The 64K-bit memory chip is in mass production, and several companies are producing the 256K-bit memory chip in quantity. (An October 1984 magazine article indicated that one company had recently reduced the price of 64k-bit memory chips to $1.85.) Indeed, several companies have been successful in producing 512K-bit or 1024K-bit memory chips on an experimental basis.

The inexpensive microcomputers five years from now will be based upon hardware currently in mass production. Thus, it will have a more powerful CPU and larger primary storage than most equipment currently in schools. More expensive systems will draw upon hardware that is currently in limited production or just now coming out of research labs. And we can dream about what lies still further down the road. A recently formed consortium of companies in the United States is talking about producing a four megabit memory chip before the end of this decade! Imagine owning an easily portable microcomputer with a 32-bit CPU and a couple of megabytes of primary memory. But 10 years from now that could be commonplace.

Certain aspects of the future of educational software can also be predicted with some confidence. The trend of improved quality software will continue. This is only common sense. The educational software market is both highly competitive and divided among a very large number of competitors. Each competitor studies the products already on the market, trying to determine what is good. New products are designed to compete against the best currently available. Poorer quality products are redone or eventually lose market share.

Another aspect of educational software is the implementation of educationally-oriented versions of business packages. The *Bank Street Writer* provides the classical example, making a good quality word processor available to young students. It is fun to see that a new version of *Bank Street Writer* has recently appeared on the market, and that it is far superior to the original version. We can expect to see student-oriented versions of spelling and grammar checkers, electronic spreadsheets, graphics packages, database systems and so on. These will be integrated into user-friendly and easy-to-learn packages.

Another major trend is toward larger, more complete computer-assisted learning packages. For example, several companies are working on and/or beginning to market major packages of material designed to help students learn to read and write. Such materials are to be used by students over a sequence of years and are a major supplement to current modes of instruction. The future will bring us major computer-assisted learning packages that cover all of the academic disciplines. Reading, writing and arithmetic are the obvious first choices for companies making the large financial commitments that are necessary.

A final trend is the production of software that ties in closely with existing textbook series. It is evident that textbook series will be with us for many years to come. More and more of them will be accompanied by software designed to supplement and enhance the texts. Quite a bit of this software will be developed and distributed by the publishers of the textbook series. However, some of the software will be produced and marketed by smaller, independent developers, and may be useful across a wide range of textbook series.

In light of these predictions and the growing amount of computer facility available to schools, we can ask some hard questions. For me, the hardest is, "How will computers improve the overall quality of education students receive?" A less biased variation on this is, "Will computers make a significant difference in the quality of our educational system?" I have spent considerable time thinking about this question and want to share some of my thoughts.

It is now evident that our school systems will be able to help all students gain an appreciable level of computer literacy, no matter how this term is defined. Students will encounter computers beginning in the primary grades and will grow up using computers as an aid to learning.

Computer programming is one important component of computer literacy. There is a growing trend toward having most students receive some introductory formal instruction in the rudiments of programming, perhaps using Logo in the elementary school or BASIC in the middle school/junior high school. For the most part, instruction in programming will be a self-contained, add-on part of the curriculum, not affecting what the student does during the remainder of the day or in subsequent non-computer courses. Without constant use and additional instruction, most students quickly lose their initial computer programming skills.

When THE QUESTION is matched against this potential progress, I feel the question remains unanswered. Achieving such a modest aspect of computer literacy—exposing all students to introductory computer programming—seems to me to be a worthy goal, but its overall impact upon the quality of a student's education is minimal.

It is frequently suggested that the computer as a tool, as in word processing or mathematical equation solving, will have a significant impact. Certainly professional writers and professional engineers appreciate such tools. But so far we have little solid research evidence that such tools can have a significant impact upon our precollege educational system. Indeed, even in higher education institutions with ample computer equipment, we have trouble seeing that such computer applications have had an appreciable impact. The potential seems large, but the potential has not yet been achieved.

Progress in computer-assisted learning is quite promising. Research on good quality CAL materials often suggests that students learn as well, have as good an attitude and learn faster. Many studies have reported CAL-based learning occurs 15% to 25% or more faster than conventional classroom-based learning. These studies tend to report long term retention rates and student attitudes equivalent to those produced by conventional instruction.

If our schools continue to pour large quantities of money into hardware and software, then in a few years we might expect to have 10 times the current level of computer facility. This will be quite difficult to achieve since there are substantial competing demands for these funds. A gain by a factor of 10 will bring us to a nationwide level of approximately one microcomputer per six to eight students. If all of this computer facility were used quite efficiently throughout the school day, an average student would use a machine for a half hour per day or more. If CAL were to be the dominant use and if this resulted in a 20-percent gain in learning rate occurred during a half hour per day, the net effect would be an average gain of about six minutes of student learning per day.

One might compare this six-minute gain with the effect of hiring quite a few teacher aides, purchasing better textbooks, assigning a little more homework, revising certain parts of the curriculum, paying good teachers more, extending the length of the school day or school year, and so on. For example, we might provide every elementary school student with a calculator and drop about half of the multi-digit long division from the curriculum. The time saved would approximate the effect of a number of years of CAL in the above half-hour-per-day model of computer usage.

The purpose of the argument is to raise questions about the wisdom of pushing hard for increased use of CAL. Of course, this type of argument is rather unfair. Consider an alternative. Suppose that we had good CAL-based courses in high school level mathematics and the sciences. If we concentrated computer equipment in schools that lack appropriate courses in these areas, then the typical student in these schools could use CAL for several hours per day throughout high school. This would surely have a significant positive affect upon those students.

The point is that while CAL has tremendous potential, the cost of achieving that potential is high and the timeline is long. The current and next-five-years impact of CAL upon our total educational system will be modest.

One can continue with this type of analysis, but perhaps the message is clear. We can deeply impact a modest number of students and we can superficially impact all students. Over the next five years, the deep impacts will most likely be in teaching quite a bit of computer programming and computer science to college-bound students, and using CAL for remediation for select students requiring such help. The overall impact upon our educational system will be quite limited.

I feel that the key issue is what comes next. During the next five years we could invest heavily in curriculum and materials development and in teacher education. This could be oriented toward integration of computers into the entire curriculum. Computer-integrated instruction entails a reexamination of the content of every discipline, searching for appropriate roles of computers in every discipline. It entails dropping substantial amounts of material from some parts of the curriculum and reorganizing other parts.

But this adding and dropping of materials cannot be a seat-of-the-pants operation. It must be based upon a careful analysis of educational goals, and it must be backed by careful evaluation of the changes being implemented. It is here that federal funding of some major project would be very beneficial. We need to have some school that have one computer per student, computer-knowledgeable faculty, and curriculum that makes appropriate use of the computer. We need to research the new ideas before moving toward wide-scale implementation.

The goal is the eventual full integration of computers into all of the curriculum, as an aid to problem solving, as a source of problems, as an aid to knowing, and as an aid to learning. The calculator and multi-digit arithmetic calculations pale to insignificance when measured against this long-term goal. But if the long term goal is achieved, it will be clear that computers have had a significant affect upon our educational system.

It is essential that computer coordinators and other educational leaders look carefully at the issue of computers in school. Our overall goal is to improve the quality of education. There are many ways to do this, and many of these ways do not involve use of computers. We must examine each major computer-related expenditure in light of our overall educational goal. We must repeatedly ask the question, "Is this proposed expenditure of funds the best way to improve our educational system?"

Appendix C

The Two-Percent Solution

Author's Note: This is a slightly expanded and modified version of an editorial written by David Moursund that was published in the March 1984 issue of The Computing Teacher. *It discusses an approach to establishing the funding of instructional computing on a sound, long-term basis. Since this article was originally published, there has been a substantial amount of inflation, and the nationwide average per pupil school expenditures have increased substantially. For the 1991-92 school year, the estimated expenditures per pupil in public schools in the U.S. was approximately $5,600. This is more than double the figure used in the original article. Even when adjusted for inflation, it represents a substantial increase in school expenditures. However, the general nature of the ideas and the arguments contained in this article are still relevant.*

I am frequently asked how much money schools should be spending for instructional use of computers. My answer is that it depends upon the goals set by the school or district.

But that answer is less than satisfying to administrators in a school district who are just beginning to make a serious commitment to the instructional use of computers. Administrators need help in determining the level of expenses and nature of the commitment that may be necessary over the long run.

With these people I discuss "The Two-Percent Solution." The idea is simple enough. Let's see what could happen if a school district budgeted two percent of its total funds, year after year, for instructional computing. Some districts might obtain this level of funding by a reallocation of current funds. But since budgets have been so tight for so long, this is unlikely in most districts. As an alternative, one could imagine the taxpayers in a district passing a special perpetual tax that adds two percent to the district's budget. Or, one might imagine a one-percent tax and a reallocation of current funds to generate the other one percent. An analysis of how two percent of a district's current budget might be used for instructional computing helps one to understand how much money is actually needed.

Two percent is an arbitrary figure, but one can find many colleges and universities that have that level of expenditure for instructional computing purposes. Also, the use of a percentage figure relates expenditures to a district's overall funding level. This is important because funding levels vary widely. A recent issue of the Wall Street Journal discussed a school in Alaska that had a budget of $16,000 per student per year. The same article noted that the average for the United States is about $2,500 per student per year, with some states having an average per-pupil yearly expenditure of under $2,000.

Where will the two percent go? I suggest four major expenditure categories of expenditures, with a reasonable level of funding for each. A fifth category, a contingency fund, is suggested to take care of unforeseen expenses. Keep in mind that these are merely suggestions; they can lead to insight into what a particular school district might do.

1. Hardware: Approximately one-half of the total funds.
2. Software, print materials, and other support materials: Approximately one-sixth of the total funds.

3. Inservice education: Approximately one-twelfth of the total funds. This provides initial and continuing training for administrators, teachers, support personnel, and aides.
4. Computer coordinators: Approximately one-sixth of the total funds. This might be used at both a district and a school building level.
5. Contingency: Approximately one-twelfth of the total funds. In the first year all of this might be used to supplement inservice education. In subsequent years it might be used in the other categories or for some new purpose, such as remodeling a room for a computer lab.

This sort of allocation assumes that office space, janitorial services, ongoing administrative and staff support, and other miscellaneous expenses will be part of the general school district budget and will not be specifically deducted from instructional computing funds.

To make this concrete, suppose we look at a school district with 5,000 students and a budget of $2,500 per student per year. The two-percent solution allocates $50 per student per year for instructional computing.

	Category	**Per Pupil**	**Total**
1.	Hardware	$25.00	$125,000
2.	Software & Materials	$8.33	$41,667
3.	Inservice Education	$4.17	$20,833
4.	Coordinators	$8.33	$41,667
5.	Contingency	$4.17	$20,833

The figure that initially tends to be most interesting to school district administrators and computer coordinators is the money for hardware. What can one buy with $25 per student per year? The answer obviously depends upon the particular equipment being purchased. A recent (winter, 1984) ad in my town's local newspaper indicated one could purchase a 64K machine with one disk drive, printer and monochrome monitor at a retail price of $900. The ad was for a very widely sold computer system from a reputable local dealer. This, of course, was a special sale price. However, school districts that go out for bids can usually obtain a discount of approximately 30 percent off the list price. That level of discount would have brought the price of this particular equipment to under the $900 figure.

The $900 figure might be considered adequate for a low-to-middle-priced microcomputer that has been on the market for a couple of years. You can expect that the quality of machine that this amount of money can buy will continue to improve rapidly in the future. Many school districts are purchasing more expensive microcomputers. The price of such newer, more expensive models may well decrease 20 percent a year during the first few years they are available.

Now a couple of assumptions are needed. A typical school doesn't want a printer on every microcomputer, and it's likely the school will want some dual disk systems. As a school obtains a quantity of machines, it is likely some will be networked using a floppy or hard disk system. This may cut the average cost of a user station. Let us assume that the average cost of a user station will be about $900. Let's also assume that such systems will have a four-year life span, with maintenance costs averaging $100 per machine over the four years. An equivalent way of expressing this is to assume that $1,000 provides a user station that functions for four years and is then completely worn out. The hardware cost is $250 per machine per year.

A particular school district may decide to purchase computers costing much more than is assumed above. Such machines might have a longer life span, different maintenance costs, and so on. For example, one might find that a machine whose initial cost is $1,600 will last five years, requiring perhaps $200 of repair and maintenance during that time. The average hardware cost per year is $360.

It is instructive to study an explicit example. We will continue the example based upon a machine costing $1,000 over a four-year time span. The first year's funds would purchase approximately one machine per 40 students. (Note: This editorial was written in January 1984. At that time there was an average of approximately one machine per 120 students in the United States and Canada. The first year's hardware funds in the two-percent proposal would purchase about three times as many machines as were already in the schools.) The second year's funds would bring the average to one machine per 20 students; the steady state situation in the fourth and subsequent years would be one machine per 10 students. This analysis ignores whatever computers a district might initially own.

An average of one machine per 10 students is equivalent to about a half-hour of machine time per student per day. If computers are going to have a significant impact upon our overall educational system, we should be able to see the beginning of the impact with this average level of computer usage.

This hardware analysis suggests that an average school district, by spending one percent of its budget every year for hardware, will eventually have about one microcomputer per 10 students. Very few schools have yet achieved such a ratio. If computer prices continue to decline, or if machines have a longer life span, then an even higher ratio will be achieved. Alternatively, if a district selects more expensive hardware, it will achieve a lower ratio of machines per student.

The same sort of analysis indicates that if a school district allocates two percent of its budget strictly for hardware, it will eventually achieve a ratio of one machine per five students. A hardware allocation of five percent of the annual budget leads to a ratio of one machine per two students.

The money allocated for software, manuals, books, films, and related support material is substantial but may prove inadequate, as classroom sets of textbooks and expendable workbooks may be quite expensive. One way to analyze this is to look at various categories of instructional computing. The categories I use are learning/teaching about computers, learning/teaching using computers and learning/teaching incorporating computers. Each category requires differing amounts and types of software, support materials, and teacher knowledge.

Learning/teaching about computers may require relatively little software beyond the language translators and operating system. It does require books, films and other media, and it requires quite knowledgeable teachers. (The suggested tradeoff between teacher knowledge and costs for hardware or software can occur in each type of computer usage.) Learning/teaching about computers is done in a self-contained classroom, with the instruction being done by a computer teacher. In our overall model, the cost of teachers is not included. Such costs are considered to part of the ongoing costs of the school system.

Learning/teaching using computers (usually called computer-assisted learning) can require a substantial software library. A particular computer simulation, for example, might be used only once or twice per year. Currently the costs of such software are high and the total quantity of good software is still quite limited. We can expect a continued rapid growth in the availability of good computer-assisted learning software. We will probably find that vendors will make available multiple copies of software, or software for local networks, at quite good prices.

Learning/teaching incorporating computers requires changes in the content of the conventional curriculum. A typing course might become a word processing course, requiring word processing software and perhaps a typing tutor program. A bookkeeping course might be substantially changed by providing electronic spreadsheet and accounting software. A science lab might be changed by use of appropriate hardware and software for the online control of experiments and the collection and processing of data. A math course might require a substantial library of graphic, equation-solving, and symbol-manipulation software.

A different way to view this expenditure category is that each machine will have $333 of software and other support materials. This is quite a bit if all of these materials have a long life span and can be used by a variety of students. For example, a single rental film might be viewed by many hundreds of students and a reference book may be useful for several years. By appropriate scheduling, a few copies of a particular historical simulation might be used by students in schools located throughout a large school district. A growing district-level lending library of commercial software might be supplemented by carefully screened public domain software. Of course, such a central library will need to be staffed. Such costs are considered to be part of the funds included in the two percent figure.

The money for inservice education of administrators, teachers, support personnel, and aides will allow for initial and continued growth in their knowledge and skills. If a district has not yet put much money into computer-related inservice education, the first year's expenditures probably need to be above one-twelfth of total funds. This can be done by drawing upon the contingency fund. Many districts have already provided such initial inservice computer exposure to all of their teachers and administrators.

It is important to realize that inservice education must continue beyond the initial effort. The level of knowledge needed when there is only one microcomputer per 120 students is quite different from what is needed when there is one microcomputer for every 10 students. At this level we could begin to see substantial changes in the content of current non-computer courses. This will require extensive inservice education as well as funds to support curriculum development and revision.

The funds and training effort need not be evenly spread among all educators. Likely it will prove desirable for each school to have a building-level coordinator with some release time from regular teaching duties. Alternatively, a building-level computer coordinator might receive a salary increment for handling these extra responsibilities. In either case the funds would come through the two percent allocation.

While all educators need an elementary working-tool level of computer knowledge, building-level coordinators will need substantially more knowledge as part of their jobs. They will be doing inservice education of teachers and administrators in their buildings. They will be training aides, helping in the acquisition of hardware and software, and doing other things requiring a high technical level of training in the computer field. Some of the inservice education funds could be used to facilitate this much higher level of training.

One use of some of the coordinator funds was mentioned above—to provide some release time for building-level computer coordinators. But consider the need for a coordinator (and a staff if the district is large) at the district level. In four years a 5,000-student school district will have about 500 microcomputer systems valued at approximately a half-million dollars. The district may have several hundred thousand dollars invested in software and other support materials. This is a substantial investment. A district computer coordinator will have a wide range of duties, including supervising hardware and software acquisition, assisting in a large inservice education program, and working with curriculum committees to integrate computers into the curriculum.

The fifth category, the contingency fund, can be used for a wide variety of purposes. As stated earlier, it might be used to supplement teacher inservice monies, especially in the beginning, or for remodeling.

Funds could be provided for:

- Accessing large-scale data banks.
- Designing and implementing a narrow-band or broad-band network for the school district.
- Special-purpose peripherals such as videodisc equipment.
- Hardware and software for students to borrow for home use.
- Establishing a community (neighborhood) school to provide community access to instructional computing equipment.

Possible uses of the contingency fund seem endless.

The Two-Percent Solution provides an interesting model to explore certain aspects of the future of computers in instruction. Most important is the idea of a permanent commitment to a reasonable level of funding. Most school districts have not yet made this sort commitment. They are purchasing equipment using entitlement funds, block grants, grants from foundations, money from parent-teacher organizations, and so on. They are giving "one-shot" teacher training workshops with little or no follow-up or opportunity for deeper training. They have not yet done the necessary planning for computers to have a significant and continuing long-term impact upon the overall content and process of education.

Two percent is a good initial goal. It is enough money to establish a solid program of instructional use of computers. However, two percent will probably prove quite inadequate over the long run. Perhaps a few years from now I will be writing an editorial on the five-percent solution. That is closer to the level of funding that will be necessary if we want to provide one microcomputer per two students, a good goal to aim at in the next decade.

Appendix D

Back To Basics

Authors Note: This editorial written by David Moursund was first published in the August/September 1984 issue of The Computing Teacher. *It is an argument that use of computers should be considered part of the "basics" of education.*

Reading, writing and arithmetic—the 3 Rs. Some computer educators become so enamored with computer potentials that they forget why the “basics” are so named.

Reading provides access to information. A book is an inexpensive, easily portable vehicle for transmitting large quantities of information over time and distance. Reading provides access to quite a bit of the accumulated knowledge of the human race. Reading is also a form of entertainment.

Writing provides the materials to be read. Equally important, writing is an aid to the human mind as it works to solve a variety of problems. For example, writing provides temporary storage of ideas as I work out the order and details of a workshop or lecture I intend to present.

Arithmetic also serves two major purposes. Numbers can represent quantities or location, distance, time, area, volume, and other measurements. Arithmetic (more generally, mathematics) provides a language to represent, store, and access these types of information. As with reading and writing, quantifiable information can be transmitted over time and distance. The geometric theorems of Euclid are as valid today as they were 2,000 years ago.

Arithmetic is also an aid to problem solving. If a problem can be represented using the notation and ideas of arithmetic, then one may be able to solve the problem using the accumulated knowledge and the tools of this field. The tools include operations such as addition, subtraction, multiplication, and division; other tools include drawing diagrams and graphs.

As an educator, it is important that you understand the 3 R's. As a computer educator, it is important that you understand how computers interface with and possibly affect the 3 R's.

The role of reading and writing as aids in transmitting information over time and distance has been indicated. A number of other aids have been invented. The telegraph and telephone certainly revolutionized communication over long distances. Photographs and movies, radio and television, phonographs and tape recorders, computers and laser discs—all aid communication over time and/or distance. The telephone is particularly interesting. It takes some training to use a telephone. But what is mostly required is a level of speaking and listening skills that people can usually acquire without benefit of formal education. Thus, while formal training in use of telephones is required for some jobs, telephone literacy is not part of the school curriculum.

Right now computerized telecommunication systems, data banks, bulletin boards, and teleconferencing seem rather esoteric to many. The suggestion is that learning to use such aids to communication is difficult and requires extensive formal training, even though using them is mostly a matter of reading and writing (typing). That is mainly true because such facilities are still relatively expensive and not readily available, and because the people-machine interfaces need additional work. Children who grow up with ready access to such facilities will find that they are easy and convenient to use. Reading and writing will remain basics, but they will be supplemented and extended by computerized aids to communication.

I want to make two additional points about some of the modern inventions. First, each new invention such as radio or television broadens the scope of communication. It takes substantial training and experience to be a skilled radio broadcaster or television producer. But generally it takes little formal training to be a user of these new inventions. The knowledge and skill needed to use the inventions is decreased by the development of appropriate people-machine interfaces. One sees this in modern cameras and in television sets.

Second, some inventions actually decrease or substantially change the type of training and experience important to the basics of education. The typewriter has decreased the relative importance of being able to write very neatly and rapidly. It does take training to learn touch-typing. But elementary school children can learn to type, rapidly acquiring useful skills. As a second example, consider learning to use a card catalog and to search library stacks versus learning to use a computerized information retrieval system. The latter will eventually be an easier and a far more reliable means of securing desired information. Notice in both examples that reading and writing are necessary skills and that the usefulness of the skills is expanded by inventions.

Increasing the Power of Basics

We have also indicated that reading and writing are aids to organizing ideas. Consider what you do as you prepare to write a paper or prepare to give a lecture. Consider the nature of the notes you take during a lecture or a staff meeting. To me it seems clear that an easily portable word processor may satisfy some of the same needs. But for me, such a tool will never replace pencil and paper for doodling during an incomprehensible talk or a dull staff meeting. Moreover, pencil and paper remain an excellent tool for prewriting and other organizing processes.

And that brings us to arithmetic. A calculator can aid in addition, subtraction, multiplication, and division. A computer can draw graphs, solve equations, and carry out complicated symbol manipulations. But these things are meaningful and useful only if one has mastered the vocabulary, notation, and methods of representing problems in mathematical form. Electronic technology is a wonderful aid to parts of arithmetic, and its ready availability suggests changes in the nature of mathematics education. There can be less emphasis upon routine manipulation and more emphasis upon higher-level cognitive processes. But the need to learn vocabulary, notation, what types of problems can be solved, and the representation of problems as mathematics remains. And so far, no computerized system approaches pencil and paper as an aid to organizing one's thoughts and trying to figure out how to represent or to solve a math problem.

Long Live Basics!

The point to be made with each of the 3 Rs is the same. Computers do not decrease the value of reading, writing, and arithmetic. But computers are an aid to accomplishing the underlying purpose of each of the basics. Thus, the ready availability of computers actually tends to broaden the scope/nature of each of the basics and thus places an additional burden on our educational system unless we change the system somewhat. I think that gradually computers will be assimilated into the definition of each of the three basics. Eventually the term “writing” will include keyboarding and use of a word processor. The term “reading” will include accessing information from computerized data banks. The term “arithmetic” will include making use of calculators and computers as aids to problem solving. And the basics will stay basic.

Appendix E

The Fifth Generation: It's for Real

Author's Note: This editorial written by David Moursund was first published in the April 1985 issue of The Computing Teacher. *It addresses some potential impacts of artificial intelligence on education.*

Recently I attended a talk given by Pamela McCorduck. She and Edward Feigenbaum are co-authors of *The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World*. The revised and updated second edition was published in paperback in 1984 by Signet. I found the book interesting because I have taught artificial intelligence courses and have had a long-term interest in this field.

The Fifth Generation is about a 10-year Japanese project (now into its fourth year) that proposes great progress in both hardware and software, with the ultimate result to be a computer system that exhibits a high level of artificial intelligence. The book describes the project as well as competing work going on in a number of other countries. A major theme of the book is that the United States is losing its computer lead and may well fall behind the Japanese.

Both in reading the book and in listening to Pamela McCorduck talk I was struck by the "hype." There appears to be a concerted effort to awe us by the potentials of faster machines, better software, and artificial intelligence. The message seems to be "Watch out! The Japanese are coming! We must do something!" The book contains a flavor of global warfare.

What is this "fifth generation," and what difference might it make to education? Is it mainly hype, or is it for real?

My feeling is that the fifth generation is quite important and will eventually help change the basic nature of education! Beneath the hype is a culmination of computer progress that is important to all of us. The following discussion of computer "generations" supports my thesis.

Many years ago it seemed easy to keep track of the generations of computer hardware. The first generation was characterized by vacuum tubes, the second by transistors, the third by integrated circuits. That hardware classification approach carried us through the 1960s, but then it began to run into trouble. There is an easy distinction between a vacuum tube and a transistor; there is an easy distinction between an individual transistor and an integrated circuit containing a number of transistors and other components. But where does one go from there?

Progress in integrated circuitry continued smoothly, with no gigantic breakthrough. But some hype was needed to publicize the progress and to help sell new hardware. So eventually we had fourth generation computers, employing large scale integrated (LSI) circuitry or very large scale integrated (VLSI) circuitry.

Now people talk about the fifth generation of computer hardware. It is characterized by the use of still larger and faster VLSI circuitry, very large primary and secondary storage, and parallel processing (employing a large number of processing units). But such fifth-generation hardware is not spectacularly different from fourth-generation hardware. It is only when we also look at software progress that we begin to understand the significance of fifth-generation computer systems.

The progress in systems software, and computer languages has been steady, if not as spectacular as hardware progress. Early computers had essentially no operating systems. One user would have complete control of the machine, doing a "cold" start. The bootstrap process of first keying in or in some other way loading a program that would load one's main program was representative of first generation systems software. The early programs were written in machine or assembly language.

Soon we got more sophisticated assemblers, higher-level languages with their compilers, and an operating system able to process a stream (batch) of jobs. Input and output were handled by card-to-tape and tape-to-printer systems that operated simultaneously with the central batch processing system. That represented the second generation of systems software.

Progress continued, and we got quite sophisticated disk operating systems that handled batch processing, multi-tasking, and the early efforts at timeshared computing. Application libraries grew rapidly and user interfaces became more friendly. These ideas characterize a third generation of software.

The fourth generation of software is represented by where we are now, with better user interfaces, easier access to databases, networking, and more powerful programming languages. As with the hardware generations, there is no clear line of demarcation between third and fourth generations.

But the next generation of software does represent a significant jump. In simple terms, it has two major parts. First is an operating system and programming languages that can take advantage of parallel processing. It is difficult to appreciate how hard it is to take advantage of having thousands or perhaps hundreds of thousands of processing units all working on a single problem. But significant progress in this endeavor could well produce computers that are many thousands of times as fast as current machines.

The second major part is artificial intelligence (AI). AI researchers work to computerize some of the knowledge of an expert or a group of experts in a particular problem-solving domain. Progress in AI has been steady, but is not characterized by distinct generations or spectacular breakthroughs. Perhaps the most obvious sign of this progress is found on the front covers of many leading magazines in the past two years. Artificial intelligence has become commercially viable. Many companies believe that it is now profitable to solve or help solve a number of problems using AI techniques.

The problems that AI is attacking are very difficult. It is only now, about 40 years after the first electronic digital computers, that the necessary hardware, software, and computer science progress are combining to produce significant results. The term “fifth generation” is a shorthand way of representing this progress and the goals for the next decade. A reasonable level of success is guaranteed, in that rapid evolutionary progress will continue in hardware, software, and computer science. No spectacular breakthrough is necessary to produce computer systems that are increasingly capable of solving more and more problems that once were only in the province of very highly qualified human experts.

Judging from computer history, progress represented by the fifth generation will gradually filter down into the computer systems that educators, students, and others can access on a daily basis. Eventually fifth-generation hardware, software, and ideas will become commonplace.

The educational implementations are profound. A very simple example is provided by the potentials for voice input. If voice input becomes readily available, should we teach typing, cursive handwriting, or printing? Or consider problem solving in the sciences and mathematics. If a computer can solve a particular category of problem, should students be required to learn to solve the same type of problem by hand?

These questions suggest that education must change to reflect people having easy, everyday access to very powerful machines. Moreover, they point to the equity of access problem. The analogy with access to books is instructive. In some sense public libraries and the fact that books are relatively inexpensive have kept the equity of book access problem under control. But computers are much more expensive than books, and we don't have anything like a public library system for free access to computers. It seems evident that some people will have the financial resources to take advantage of newer computer systems, and others won't.

Even these questions seem easy when compared to questions that arise as one begins to consider the creation of very large-scale data banks of knowledge that can be accessed and processed by artificially intelligent computer systems. The creation and maintenance of such systems may initially be quite dependent upon federal funding. Who will control what "facts" go into the data banks? Who will control the type or nature of the "reasoning" that will be programmed into the computer systems? For example, consider questions related to a social system. There are considerable differences of opinion between Democrats and Republicans as to the correct answer or lines of action for many questions. Our military-industrial complex may have still another view that it feels is correct.

Such questions place still additional burdens on educated people and their educational systems. The issue of fifth generation computers is not "Watch out! The Japanese are coming." Instead, the issue is "Watch out! Fifth-generation computers are coming!"

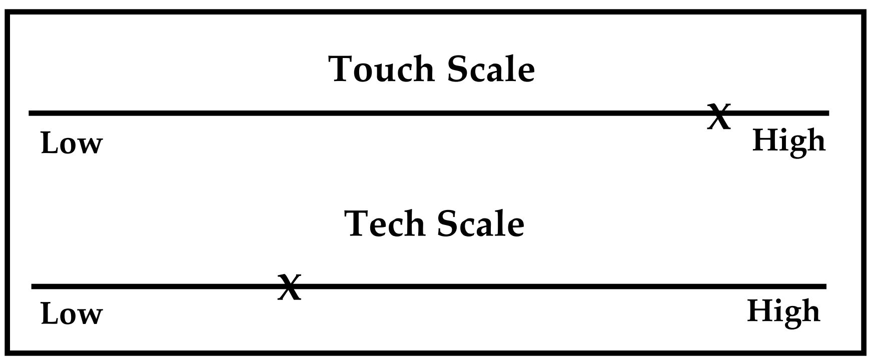
Appendix F

High Tech/High Touch

Author's Note: This editorial written by David Moursund was first published in the November 1985 issue of The Computing Teacher. *It focuses on the central importance of people skills and human values as more and more technology is introduced into schools.*

John Naisbitt's *Megatrends: Ten New Directions Transforming Our Lives* was first published in 1982. It was a best seller and has won considerable acclaim. The second chapter of the book is titled "From Forced Technology to High Tech/High Touch." In that chapter Naisbitt suggests "that whenever new technology is introduced into society, there must be a counterbalancing human response—that is, high touch—or the technology is rejected."

Naisbitt's high tech/high touch paradigm has interesting implications for computer education. Consider two scales, one labeled "tech" and the other labeled "touch," each running from low to high. The paradigm supports a conjecture that a person lies at some point on the "tech" scale and at some point on the "touch" scale. Whatever a person's placements on these two scales, the placements balance each other within that person's lifestyle. The diagram below shows a person who is quite high in "touch" and a little below the middle in "tech."



The introduction of increased technology into a person's life produces an imbalance. For a person whose "tech" placement is high, additional technology represents only a modest percentage change and perhaps requires relatively little adjustment of "touch" to maintain a balance. But for a person placed low on the "tech" scale, even a modest amount of new technology may require a considerable adjustment to "touch."

High tech/high touch is a simple-minded paradigm, perhaps most useful for provoking discussion rather than for providing a foundation to support educational change. But let's explore the paradigm a little more. We might guess that early adopters of computers were high-tech people. (At the same time, they might be at any spot on the "touch" scale.) Such high-tech people found it easy to adjust to computer technology and are now well established as computer leaders and teachers.

But as we attempt to introduce more and more people to computers, we soon move beyond the readily available supply of high-tech people who might be interested in computers. We begin to experience increased resistance as we attempt to introduce high-touch people to computer technology. Moreover, we have the added difficulty that the current computer leaders and teachers have a high-tech orientation, while the people they are attempting to teach have a high-touch orientation. These differences in orientation make effective communication difficult!

In recent years I have grown to understand some of the differences between high-tech and high-touch people. On a "touch" scale I have moved in the direction of higher touch. (I doubt if I have reached the midpoint yet, since I started so close to the low-touch end. But I am pleased with the progress I have made.)

Gradually, over the past eight years, I have experimented with increased use of high-touch ideas and activities in the computer education workshops I present. In recent years I have grown in ability to teach and make use of active listening, guided fantasy, small group discussion, large group interaction, and other high-touch techniques. These ideas, and others, are included in my Computer Education Leadership Development Workshop. The workshop even includes a substantial session on Stress and Burnout.

Another session in the workshop examines similarities and differences between mathematics education and computer science education. I view mathematics as a high-tech discipline—as the queen of the sciences—even though it differs from other science disciplines and their related technologies. We know that our mathematics education produces math anxiety and an "I can't do mathematics" syndrome among many people. Do we want the same results in computer science education?

Our mathematics education system is predicated upon two major assumptions. First, all people need to be able to do mathematics at a moderate level in order to survive in our society. Second, our society needs a number of professional mathematicians and other people who can function at a relatively high level in mathematics.

Thus, formal instruction in mathematics begins in the first grade or earlier, and a spiral curriculum approach is used in subsequent grades to ensure that almost all students develop a moderate level of mathematical knowledge. Beginning roughly at the junior high school level, our mathematics education system begins a process of separating off students who display good mathematical talent and learning ability. Others are discouraged by the system. They learn that they can't do mathematics as well as some of their colleagues and teachers; they feel insecure in their mathematical knowledge and perhaps get poor grades.

Early efforts to introduce computers into elementary and secondary school education tended to follow the mathematics education paradigm. That is not surprising, since much of this early teaching was done by math-oriented early adopters of computer technology. Moreover, there was considerable rationale to this approach, since computer programming and the underlying computer science seemed to be necessary in order for a person to use a computer.

But now we are moving beyond the early adoption stage. Many elementary schools, for example, are moving toward involving all of their teachers and all of their students in working with Logo. Some are developing a spiral curriculum scope and sequence that has many characteristics of a mathematics scope and sequence. It is my guess that this approach will soon produce junior high school students who assert "I can't do computers."

The mathematics paradigm, for an elementary school computer curriculum is not the only possible paradigm, and it may not be the most appropriate one. Progress in computer software and hardware has made it possible for people to become effective users of computers without knowledge of the underlying computer programming and computer science. A "survival" level of computer-use skill is easily obtained without learning how to write programs. A spiral curriculum of computer science instruction need not begin in the first grade to develop high school graduates with a survival level of computer science knowledge. Nor do we have evidence that the supply of computer science graduate students will be diminished if computer programming is less emphasized at the precollege level.

This type of analysis suggests that we might look for other, more appropriate paradigms for computer education, especially at the lower grade levels. Perhaps art education provides a more appropriate paradigm. Art education tends to be quite high touch. Students explore the art media; they frequently set their own goals; they evaluate their own work and the work of others. Some elementary schools have taken the approach that Logo should be introduced using the art education paradigm. Naisbitt's high tech/high touch ideas suggests that this approach will be more successful than approaching Logo using a mathematics education paradigm. I have talked with several elementary school teachers who have used this approach and who feel that it is very successful.

The high tech/high touch paradigm can be used to examine other aspects of computer education. In my Computer Education Leadership Development Workshop I often ask participants to rank a set of computer coordinator qualifications that are essential to being a successful computer coordinator. I have now used this activity in a half-dozen workshops. In every workshop the participants listed “Interpersonal and Communication Skills” as most important and “Technical Skills” as least important among the four general qualifications being rated. These workshop participants, many who are successful computer coordinators, are suggesting that high touch is more important than high tech.

My conclusion is that the high tech/high touch paradigm provides a useful approach to examining many aspects of computer education. I am sure you can think of your own examples and issues—such as whether extensive use of CAI will damage social development and skills. I'd like to hear from you about your examples.

Appendix G

The Information Explosion

Author's Note: This editorial written by David Moursund was first published in the December/January 1986/87 issue of The Computing Teacher. *It focuses on the very rapid growth in information and the need for major educational changes in order to prepare students to adequately deal with the information.*

Every once in a while I come across a statement that the totality of human knowledge is doubling every N years. Depending on the author, N might be as little as four years or as many as 12 years. All of the authors are trying to capture the idea that we have increasing numbers of researchers who are using increasingly sophisticated tools to build on the work of previous researchers. We have an explosive, geometric growth of accumulated knowledge.

Generally, people don't carefully define what is meant by the totality of human knowledge. I suspect that this is difficult (if not impossible) to do, so I won't attempt it in this short editorial. However, I have a picture in mind that comes from my days as a student of mathematics. I picture mathematics as a broad-based, but relatively vertical discipline, with the research frontiers built on hundreds or even thousands of years of solid progress. Researchers in a university discuss some of their new ideas in graduate research seminars. A few of the ideas filter down to regular graduate courses. Over a period of decades some of these ideas enter the undergraduate curriculum. Over a period of hundreds of years, some of the ideas enter the precollege curriculum. For example, most of the precollege "new math" movement of the 1960s was based on math that was well over a hundred years old.

A troubling factor in this information explosion is that the capabilities of the human mind do not appear to be increasing. This leads to the situation that a student beginning the study of a particular discipline will be able to learn a decreasing percentage of that field. Scholars who want to become researchers in a particular field respond by selecting narrower and narrower areas of specialization.

But what is the ordinary student or the generalist to do? How can one gain a solid grasp of a wide variety of fields, understand progress that is occurring, make use of the new knowledge that is being developed, and feel intellectually comfortable with the rapidly growing base of human knowledge? These questions are fundamental to the Information Age.

The answer lies in learning to build on the work of others—to avoid reinventing the wheel. This is the guiding principle of much of our academic coursework. The goal is to help students rapidly learn what researchers and scholars struggled with for years. For example, Newton and Liebnitz invented the calculus about 300 years ago, and this was a monumental achievement. But some high school students now learn more calculus than these initial researchers knew, because we have very good calculus books and calculus teachers.

Mathematics provides a good example of the progress we can make through coursework, but also illustrates the major dilemma. As a rough estimate, I would guess that over the past 100 years a significant percentage of the college mathematics curriculum has been moved to two years earlier in the curriculum. That is, freshman and sophomore mathematics majors study a great deal of material that was common in the junior and senior curriculum of a hundred years ago.

But unfortunately, during that time the totality of mathematical knowledge may have increased by a factor of several hundred! Moreover, there has been an explosive growth of knowledge in many other disciplines. And new disciplines have arisen, such as computer science and genetic engineering. Thus, there are ever-increasing demands on the student's time and learning capabilities.

Continual development of new curricula, better texts and learning aids, and better teaching methods are all essential and helpful. However, the fundamental issue is whether we can find still other ways to build on the work of others.

Computers offer a new, two-part answer. The first part of the answer is computer-assisted instruction. Research evidence strongly supports the contention that via CAI many students can learn significantly faster. For this reason it seems inevitable that CAI will eventually be commonplace in our schools.

The second part of the answer lies in computer-as-tool for the storage, processing, and retrieval of information, and as a general-purpose aid to problem solving.

One can view a computer system as a passive information storage and retrieval device. In that sense it is like a library. But it is a significantly changed library. A 12-cm CD-ROM can store the equivalent of 500 books. A videodisc can store 54,000 pictures. Our telecommunications systems can provide easy access to computerized materials stored at distant locations. It is evident that computers, telecommunications, and storage technology are significantly improving our access to information. Such access is essential to building on previous work of others.

However, the key to dealing with the information explosion does not lie just with improved (passive) access to information. The key mainly lies with the ability of computers to process the information. Computer storage of information differs significantly from library storage of information precisely because computers can also process the stored information.

For example, a computer can store demographic information along with maps, programs to represent the data on maps, programs to graph the data, programs to extrapolate trends, programs to perform statistical analysis such as correlating sets of data, and so on. These software tools can help solve some of the problems one addresses through use of the data. Such computer capabilities truly represent an extension of the human mind.

Essentially all of computer science is concerned with such extension of the capabilities of the human mind. However, artificial intelligence focuses specifically in this area. Recent progress in artificial intelligence, including knowledge-based expert systems, is exciting! In essence, AI researchers have given us a method for capturing some of the knowledge of a human expert in a form so that the computer can use it to solve problems. A human can learn to use such a system, and thus to solve some problems at the level of an expert in a particular discipline, without spending the time necessary to become an expert in the discipline.

All educators should be following this progress, since it is at the very heart of a new interface between education and the information explosion.

I draw two conclusions from the line of reasoning discussed above. First, schools should focus increased attention on information storage and retrieval, and they should place particular attention on computer-related improvements in this field. Second, within every discipline, students should learn to use computer-as-tool as an aid to solving the problems of the discipline. The capabilities and limitations of computer-as-tool should be a clearly defined part of every academic course. This capability is our current best new aid to coping with the information explosion.

Appendix H

Lower-Order and Higher-Order Skills

This editorial written by David Moursund was first published in the February 1987 issue of The Computing Teacher. *It focuses on the need for schools to place greatly increased emphasis on improving the higher-order cognitive skills of students.*

I begin one of my favorite workshop activities discussing the idea of effective procedure—hat is, the types of procedures that computers can carry out—and how this relates to problem solving. I then ask the workshop participants to identify disciplines that seem to have a relatively high or relatively low concentration of effective procedures. Mathematics is usually the unanimous choice for the discipline with the highest concentration of effective procedures, although the physical sciences sometimes run a close second.

The fun begins as workshop participants start to name disciplines with relatively low concentrations of effective procedures. Art is frequently mentioned, but I then suggest that the graphical or commercial arts seem to make major use of computers. Sometimes the social sciences are mentioned. But by then some workshop participant will give a solid argument that the organization, storage, retrieval, and presentation of information is greatly helped by computers.

Eventually a pattern emerges. Each discipline has some parts where computers are very useful and other parts where computers are of modest or no use. Even math fits this pattern. Math is viewed by many mathematicians as an art form, as a field requiring a great deal of creativity, and as a field where computers are mostly useful in carrying out routine computational or manipulative tasks.

Skills for Problem Solving

Within each academic discipline there is a continuum of knowledge and skills. Bloom's taxonomy is a division of this continuum into (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis and (6) evaluation. Many educators refer to the first three as lower-order skills and the latter three as higher-order skills.

It seems evident that problem solving requires both lower-order and higher-order skills. For example, suppose one is faced by the problem of writing a descriptive narrative using pencil and paper. Then spelling, grammar, and penmanship are lower-order skills that will enter into the final product. But no matter how well these lower-order skills are used, the writing may turn out to be very poor. Good writing has style; it has appropriate and rich use of vocabulary; it communicates clearly. The production of good writing requires use of such higher-order skills as information retrieval, organization, drawing on a rich vocabulary, understanding the intended audience and the purpose of the writing, revision, and so on.

The problems in each academic discipline can be analyzed in this same way. In arithmetic, one has many lower-order skills such as writing the numerals, counting, and performing the four basic arithmetic operations. One has higher-order skills such as representing real-world problems as arithmetic computations, applying problem-solving techniques such as breaking a big problem into more manageable pieces, estimating, detecting computational errors, and interpreting computational results in light of a real-world problem that one is working to solve.

Educators have long understood the dichotomy of lower-order versus higher-order skills, and each curriculum reflects a balance between them. But even within the school systems of a single state, there may be major difference in emphasis on higher-order and lower-order skills. In some schools the balance is heavily weighted toward lower-order skills (rote memorization is stressed) while in other schools there is more emphasis on analysis, synthesis, and evaluation.

The balance between lower-order and higher-order skills can change in an educational system over a period of years. Education in the United States began a "back-to-basics" movement more than 15 years ago. This movement included increased emphasis not only on reading, writing, and arithmetic, but also on the basic skills in these and other disciplines. Now many educational leaders in the United States are arguing that the back-to-basics movement was a mistake and that we should be placing much greater emphasis on higher-order skills.

One argument for increased emphasis on higher-order skills is based on an examination of the steady decline in college entrance exam scores that extended over many years and just recently appears to have bottom out. An analysis of such test scores indicates that the basis skills component of these scores actually increased. It was the higher-order skills scores that declined drastically and dragged down the total scores.

A second argument should be made by computer education leaders. Most of the effective procedures that computers can carry out fall in the lower-order skills area. For example, in writing, one can have a word processor (as contrasted with penmanship) and one can have both spelling and grammar checkers. In arithmetic one can have a calculator. The argument is that appropriate use of computers can be a partial substitute for some lower-order skills.

To me the argument seems clear. A good education must be balanced between lower-order and higher-order skills. Computers have a greater impact on lower-order skills than on higher-order skills. For example, in a wide variety of disciplines, computers make it more appropriate to retrieve information than to memorize it. Computers can carry out routine manipulative tasks that require substantial schooling for humans to learn to perform. Thus, some of the time currently being spent on lower-order skills can be replaced by a combination of appropriate use of computers and more time spent on higher-order skills.

In several recent workshops, I have raised the idea that we might replace much of the cursive writing penmanship curriculum by keyboarding. (This idea was suggested to me by my colleague Keith Wetzel.) While there is an initial round of outright shock and laughter, the majority of participants in my workshops support such an idea! The next time you want to provoke an argument with traditional educators, you might suggest that penmanship is of rapidly declining importance. When the argument begins to wane, suggest that everyday voice input to computers is now visible on the horizon.

There are many things that people can do better than computers—especially if they have an education that emphasizes higher-order knowledge and skills. An appropriate education for the Information Age must take into consideration the capabilities of computers. The education must prepare people to work with computers, rather than compete with such machines. All computer educators should be encouraging a greater emphasis on higher-order skills.

Appendix I

Chesslandia: A Parable

Author's Note: This editorial written by David Moursund was first published in the March 1987 issue of The Computing Teacher. *It is an attack on our current educational system.*

Chesslandia was aptly named. In Chesslandia, almost everybody played chess. A child's earliest toys were chess pieces, chess boards, and figurines of famous chess masters. Children's bedtime tales focused on historical chess games and on great chess-playing folk heroes . Many of the children's television adventure programs were woven around a theme of chess strategy. Most adults watched chess matches on evening and weekend television.

Language was rich in chess vocabulary and metaphors. "I felt powerless—like a pawn facing a queen." "I sent her flowers as an opening gambit." "His methodical, breadth-first approach to problem solving does not suit him to be a player in our company." "I lacked mobility—I had no choice."

The reason was simple. Citizens of Chesslandia had to cope with the deadly CHESS MONSTER! The CHESS MONSTER, usually just called the CM, was large, strong, and fast. It had a voracious appetite for citizens of Chesslandia, although it could survive on a mixed diet of vegetation and small animals.

The CM was a wild animal in every respect but one. It was born with an ability to play chess and an innate desire to play the game. A CMs highest form of pleasure was to defeat a citizen of Chesslandia at a game of chess, and then to eat the defeated victim. Sometimes a CM would spare a defeated victim if the game was well played, perhaps savoring a future match.

In Chesslandia, young children were always accompanied by adults when they went outside. One could never tell when a CM might appear. The adult carried several portable chess boards. (While CMs usually traveled alone, sometimes a group traveled together. Citizens who were adept at playing several simultaneous chess games had a better chance of survival.)

Formal education for adulthood survival in Chesslandia began in the first grade. Indeed, in kindergarten, children learned to draw pictures of chess boards and chess pieces. Many children learned how each piece moves even before entering kindergarten. Nursery rhyme songs and children's games helped this memorization process.

In the first grade, students were expected to master the rudiments of chess. They learned to set up the board, name the pieces, make each of the legal moves, and tell when a game had ended. Students learned chess notation so they could record their moves and begin to read chess books. Reading was taught from the "Dick and Jane Chess Series." Even first graders played important roles in the school play, presented at the end of each year. The play was about a famous chess master and contained the immortal lines: "To castle or not to castle—that is the question."

In the second grade, students began studying chess openings. The goal was to memorize the details of the 1,000 most important openings before finishing high school. A spiral curriculum had been developed over the years. Certain key chess ideas were introduced at each grade level, and then reviewed and studied in more depth each subsequent year.

As might be expected, some children had more natural chess talent than others. By the end of the third grade, some students were a full two years behind grade level. Such chess illiteracy caught the eyes of the nation, so soon there were massive, federally-funded remediation programs. There were also gifted and talented programs for students who were particularly adept at learning chess. One especially noteworthy program taught fourth grade gifted and talented students to play blindfold chess. (Although CMs were not nocturnal creatures, they were sometimes still out hunting at dusk. Besides, a solar eclipse could lead to darkness during the day.)

Some students just could not learn to play a decent game of chess, remaining chess illiterate no matter how many years they went to school. This necessitated lifelong supervision in institutions or shelter homes. For years there was a major controversy as to whether these students should attend special schools or be integrated into the regular school system. Surprisingly, when this integration was mandated by law, many of these students did quite well in subjects not requiring a deep mastery of chess. However, such subjects were considered to have little academic merit.

The secondary school curriculum allowed for specialization. Students could focus on the world history of chess, or they could study the chess history of their own country. One high school built a course around the chess history of its community, with students digging into historical records and interviewing people in a retirement home.

Students in mathematics courses studied breadth-first versus depth-first algorithms, board evaluation functions, and the underlying mathematical theory of chess. A book titled "A Mathematical Analysis of some Roles of Center Control in Mobility." was often used as a text in the advanced placement course for students intending to go on to college.

Some schools offered a psychology course with a theme on how to psych out an opponent. This course was controversial, because there was little evidence one could psych out a CM. However, proponents of the course claimed it was also applicable to business and other areas.

Students of dance and drama learned to represent chess pieces, their movement, the flow of a game, the interplay of pieces, and the beauty of a well-played match. But such studies were deemed to carry little weight toward getting into the better colleges.

All of this was, course, long ago. All contact with Chesslandia has been lost for many years.

That is, of course, another story. We know its beginning. The Chesslandia government and industry supported a massive educational research and development program. Of course, the main body of research funds was devoted to facilitating progress in the theory and pedagogy of chess. Eventually, however, quite independently of education, the electronic digital computer was invented.

Quite early on it became evident that a computer could be programmed to play chess. But, it was argued, this would be of little practical value. Computers could never play as well as adult citizens. And besides, computers were very large, expensive, and hard to learn to use. Thus, educational research funds for computer-chess were severely restricted.

However, over a period of years computers got faster, cheaper, smaller, and easier to use. Better and better chess programs were developed. Eventually, portable chess-playing computers were developed, and these machines could play better than most adult citizens. Laboratory experiments were conducted, using CMs from zoos, to see what happened when these machines were pitted against CMs. It soon became evident that portable chess-machines could easily defeat most CMs.

While educators were slow to understand the deeper implications of chess-playing computers, many soon decided that the machines could be used in schools. “Students can practice against the chess-machine. The machine can be set to play at an appropriate level, it can keep detailed records of each game, and it has infinite patience.” Parents called for “chess-machine literacy” to be included in the curriculum. Several state legislatures passed requirements that all students in their schools must pass a chess-machine literacy test.

At the same time, a few educational philosophers began to question the merits of the current curricula, even those that included a chess-computer literacy course. Why should the curriculum spend so much time teaching students to play chess? Why not just equip each student with a chess-machine, and revise the curriculum so it focuses on other topics?

There was a call for educational reform, especially from people who had a substantial knowledge of how to use computers to play chess and to help solve other types of problems. Opposition from most educators and parents was strong. “A chess-machine cannot and will never think like an adult citizen. Moreover, there are a few CMs that can defeat the best chess-machine. Besides, one can never tell when the batteries in the chess-machine might wear out.” A third grade teacher noted that “I teach students the end game. What will I do if I don't teach students to deal with the end game?” Other leading citizens and educators noted that chess was much more than a game. It was a language, a culture, a value system, a way of deciding who will get into the better colleges or get the better jobs.

Many parents and educators were confused. They wanted the best possible education for their children. Many felt that the discipline of learning to play chess was essential to successful adulthood. “I would never want to become dependent on a machine. I remember having to memorize three different chess openings each week. And I remember the worksheets that we had to do each night, practicing these openings over and over. I feel that this type of homework builds character.”

The education riots began soon thereafter.

Appendix J

A Report on the All Purpose Relatively Intelligent Learner Computer

Author's Note: This editorial was first published in the April 1988 issue of The Computing Teacher. *This was my first attempt to write an April Fool's editorial. Several people read only part of it, and then quoted it in assignments that they turned in to me. They completely missed the point that it was a joke, and so quoted it as representing what exists right now. A number of other people noted that the ideas in the article were really not very far into the future. My conclusion was that I should probably give up on writing April Fool's editorials.*

It is well known that the major computer hardware systems we can purchase commercially are about five years behind the state-of-the-art products currently functioning in the research labs of companies such as International Business Machines or Nippon Telegraph and Telephone. What is less well known is that the top secret military research labs in the United States are about five years ahead of the company research labs.

A short while ago I was given a tour of one of these top secret labs. (That is one of the privileges of being Editor-in-Chief of an outstanding computer in education periodical.) Of course, they didn't show me any of the really "top" secret stuff. And I had to sign a form promising that I would not reveal the location of this research lab. But I did receive permission to write about educational implications of what I saw.

I received a personal tour with a general as a guide. What I saw really blew my mind. The computer system that most impressed me was the size of a tape cassette player and weighed about two pounds including its batteries. At first I thought it was a small CD-ROM player, and indeed that is one of its functions. The CD-ROMs it uses are about 3 CM (a little over an inch) in diameter and store one billion bytes of information on each side of the disk. The computer has two of these laser disc drives. One can only read laser discs while the other is a WORM (write once read many) drive. I think the idea is that they want to create a permanent record of every use of the computer. The computer has a small pocket on the side of its carrying case. It looked to me like it will hold several dozen CD-ROM discs.

I asked about the speed of this computer and its memory size. The general told me that it uses fiber optics, an optical central processing unit, and makes use of super conductivity. While the general didn't give me precise details (perhaps due to a lack of knowing specific details), my guess is that the machine is at least a thousand times as fast as a Macintosh II, or several times as fast as the largest Cray computer currently available. The general was unable to give me detailed information about the primary memory, but suggested it is in excess of 32 megabytes.

I couldn't see a display screen on the computer, and the whole outside case was so small that it couldn't hold a keyboard. I asked where the keyboard and the display unit plugged in.

The general laughed and handed me a bullet proof helmet with a strange looking pair of goggles. It reminded me of a World War II tank movie I had seen on television a few days earlier. The general indicated that the helmet and goggles connected to the computer via narrow band radio, with a highly secure encrypting and decrypting system used to ensure security. The same system, operating on a different channel, allows voice and/or computer contact with other people having similar communication systems. The setup includes audio output through speakers built into the sides of the helmet and voice input through a microphone built into the chin strap.

The general explained that the computer system uses voice input and voice output. But, I said, what if one needs to look at a table of data or view a map stored in the computer? And, what role do the goggles play?

Again the general laughed, and then helped me to put on the helmet and goggles. Surprise! The goggles are a heads-up computer display. That is, I could see through the goggles and have a clear view of the room around me. But when the computer was switched on, I could also see a full screen display right before my eyes!

By that time I think the general was having fun at how overwhelmed I appeared. The general showed me how to call up a map of a military training post. The heads-up display showed me a photograph that looked like it was taken from several miles up. Using spoken commands such as Lower, Higher Left, Right, Up, and Down I was able to focus in on any part of the base. One of the buildings I looked at seemed to be designed to store high explosives and there were four guards standing at the only door. The general suggested I say the word Location. When I did so, the coordinates and elevation of the building appeared on the display. I made a guess and said the word Contents. As an inventory of the building contents appeared on the display the general ripped the goggles off my face. My guess is that it was not appropriate for me to see that the building contained more than a dozen 20- megaton nuclear weapons!

Needless to say, that ended the hands-on part of my tour. Near the end of the tour I asked if I could talk to one of the programmers or some other technical person. Fortunately for me, just at that time we encountered a relatively young person in civilian clothes who proved to be a technical expert.

First I asked about what it might cost to mass produce this computer system. I was told that the military expects to produce about three million of these computer systems, with mass production scheduled to begin in 1998. In mass production, the ruggedized military version of this computer system will cost about $1,500 apiece. My guess is that a civilian version, suitable for use in schools, will cost under $400.

Next I asked about some of the technical specifications of the hardware and I asked what programming language was being used to develop the software. I guess that the general standing there rather intimidated the technical person, as the response was quite guarded. But I was told that the hardware is called the All Purpose Relatively Intelligent Learner (APRIL) computer since it makes extensive use of recent advances in artificial intelligence. The language used to write the software is called the First Operational Optical Language (FOOL).

Appendix K

CAI Versus Computer-As-Tool: Not Either/Or—But Both!

Author's Note: This editorial by David Moursund was first published in the October 1988 issue of The Computing Teacher *under the title: CAI? Not Either/Or–But Both!*

At the Spring 1988 annual conference of the Northwest Council for Computer Education, the keynote presentation was a panel discussion by Karen Billings, Sylvia Charp, Dave Moursund, David Thornberg, and Tom Snyder. LeRoy Finkel was the moderator, and the central focus was the future of computers in education.

The initial part of the discussion was a brief presentation by each panel member. The various points of view were mostly upbeat and can be summarized by:

1. Computers in education are a good idea and progress is continuing.
2. Computer-as-tool is great.
3. Routine CAI drill and practice has proven quite useful.
4. Empowering the teacher, and focusing on how to make effective use of one computer per classroom, is a great idea.
5. Teachers are wonderful. The human-to-human interaction of teacher with student is at the core of quality education.

A variety of questions from the audience focused on the same issues. Each comment about maintaining the current central role of teachers brought cheers from the audience.

As I listened to the discussion, I found myself growing more and more frustrated. Two major themes were being ignored. One was the issue of whether students in the future will be learning any "solid" computer science and computer programming. Surprisingly, no panelist made a prediction in this area, and no member of the audience raised the question. But that contributed only modestly to my feeling of frustration.

The second major theme that nobody seemed willing to raise was that of computer-assisted instruction as a vehicle for presenting curriculum units or entire courses. So, at an opportune time I mentioned the topic and suggested that it will gradually produce a massive change in education. Sylvia Charp cheered, several other panel members immediately jumped into attack mode, and many of my former and current graduate students blanched. I was pleased, in that my statement had brought increased life to the panel presentation.

As the discussion continued, it became clear that many people view computer-assisted instruction in an either/or mode. That is, they think of CAI and our current educational practices as being in direct competition. Either we maintain our current system OR we have CAI. (People who get into the either/or argument tend to forget that we already have both in many schools.)

Those who oppose CAI then go on to paint a frightening picture of children spending all day chained to a soulless, inhumane machine that assumes full responsibility for their education. Many of us are brought to the verge of tears just thinking about what a terrible thing this would be for our children.

Those who favor CAI tend to talk about increased rates of learning, teacher productivity, individualization of instruction, and an increased range of learning opportunities. The picture of children learning more, better, faster, and achieving their full potential is heart warming.

Surprisingly, the panel discussion never got beyond these two extremes. It seems inevitable to me that during the next two decades, our school systems will gradually move toward making substantial use of CAI. However, during that time span human teachers will continue to play a dominant role in the overall educational process. Computers will gradually do the parts that they do better than humans. Humans will gradually move in the direction of doing the parts that they do better than machines. We will have BOTH humans and computers deeply involved in the instruction of our children.

I enjoy discussing which aspects of instruction might gradually be relegated to computers, and which aspects are best preserved exclusively to humans. The human brain is a wonderful thing, and there are many things that humans do far better than computers. Perhaps the most important of these is having a deep understanding of what it is to be a human being. This includes understanding human verbal and nonverbal communication systems. The very best work of researchers in artificial intelligence has not yet begun to develop computer systems that even show signs of eventually leading to systems that have such human abilities. Thus, to the extent that teachers are making use of these human abilities, they can far outdo the very best of current CAI systems.

But much of the educational process is not based on intimate, one-on-one human interaction that requires use of these human communication abilities found in all teachers. We cannot afford an educational system in which there is one human teacher for each student. Moreover, it is essential that students learn to learn from books and other resource materials such as computerized information retrieval systems. Routine drill and practice is an important part of education. CAI can provide rich simulations, opportunities for trial-and-error explorations requiring higher-order cognitive processing, greater opportunities for individualized instruction than most current classrooms provide, and so on.

It seems obvious to me that our educational system would be better if it were based on a combination of well-prepared and dedicated teachers, and on an abundance of high-quality CAI. The cost of providing a computer for every student and a wide range of CAI materials is quite modest compared to our current educational expenditures. If we devoted five-percent of current annual school budgets to this task, it would soon be accomplished. I strongly believe that we should be working toward this objective.

Appendix L

Standardized Testing and Computer-Assisted Instruction

Author's Note: This editorial written by David Moursund was first published in the November 1988 issue of The Computing Teacher.

There is one sure way to get a rise out of the students in my graduate computer education courses. Just mention standardized testing and the increasing role it seems to be playing in education. Most of my students become quite agitated in thinking about this, and some become downright hostile towards the school systems where they work.

Students face a barrage of standardized tests, beginning in grade school and often continuing on into graduate school. Moreover, some teachers are now being evaluated by how well their students do on standardized tests. Increasingly, teachers themselves are being required to take standardized tests, either to obtain a teaching certificate or to maintain their teaching certificate.

The educators I work with give a variety of reasons why they are troubled by the major emphasis on standardized testing. Reasons given include that such testing is a waste of time, irrelevant to the curriculum, focuses too much on lower-order skills, and is a major force moving education in an inappropriate direction. The tests seem to be driving the curriculum—teachers are teaching to the tests and students are studying methods specifically designed to raise their test scores.

Interestingly, I pick up nearly similar feelings of disquiet and fear when my students discuss computer assisted instruction. Much of the CAI material is rather superficial, focusing mainly on lower-order skills. Deeper aspects of the human elements of teaching remain elusive to most CAI developers. There is a distinct possibility that eventually the content of CAI-based courses will become *the* curriculum.

Standardized Testing

Generally I maintain a neutral stance in discussing standardized testing. I have some understanding of the processes that have been followed in developing and evaluating the test items. I know a little about validity and reliability. And, of course, I understand some of the roles that computers now play in the overall process of developing standardized tests.

In recent years computers have played an ever increasing role in standardized testing. Two trends are evident. First, there are large data banks of possible test questions, along with item analysis and other statistical data that have been gathered through use of the test items. Thus, it is growing easier to create standardized tests or other tests with specified characteristics. Second, an increasing amount of testing is now being done online. In one type of online testing, called adaptive testing, the computer system adjusts the selection of questions to the particular person being tested, making changes based on performance during the test.

Adaptive testing has many characteristics of computer assisted instruction. Indeed, much of the CAI that is currently available can be considered as tests, with some feedback and perhaps some remedial instruction being provided while the test is being taken.

Perhaps it is the close similarity between objective testing and routine drill and practice CAI that agitates so many of my students. In both cases, a large part of education seems to be reduced to a lower-order skills, multiple-choice or short-answer format. The multidimensional aspects of a good student/teacher rapport are missing, along with much of the richness of a good classroom environment. Many educators find this objectionable. They know education has many important dimensions that cannot be measured through such a testing format.

Coachability of Objective Tests

Recently I read *None of the Above: Behind the Myth of Scholastic Aptitude* written by David Owen and published by Houghton Mifflin Company in 1985. In large, it is an attack on the Educational Testing Service and their widely used test, the Scholastic Aptitude Test (S.A.T.). But at a deeper level it questions all standardized tests. It is a powerful book, and I strongly recommend it to all educators.

There are a number of important points discussed in Owen's book. One is the nature of the standardized test questions themselves, and the fact that many questions are subject to multiple interpretation. Thus, one has to have or to develop a mind set somewhat similar to those who create the questions in order to interpret the questions in an manner leading to "the correct" answer.

But a deeper problem that Owen raises is the "coachability" of standardized tests. It is possible to teach to the test or to coach students so that they will do well on a particular test. A number of companies publish books that are designed to help students improve their test taking ability, and many of these books are geared toward a particular test such as the S.A.T. Indeed, there are now a number of pieces of software designed for the same purpose. Some companies advertise the purchase price will be returned if the user doesn't make a certain specified gain in their S.A.T test score.

Owen discusses several companies that run short courses specifically designed to help students learn to make higher scores on specified standardized tests. In these courses, students learn a wide range of tricks, almost none related to increasing their understanding of the material being tested. It turns out that because of the way standardized tests are created and the way that the test constructors think, it is possible to correctly guess answers to many questions without even reading the questions!

Earlier in this editorial, I suggested that the feelings my students have about standardized testing and about CAI seem to be similar. Owen's book has increased my understanding of this issue. The real world does not consist of a sequence of objective questions, where success is measured by one's ability to select the one correct answer from a short list of choices. But both standardized testing and most of the currently available CAI view the world in exactly this manner. Thus, both foster teaching to the test, teaching objective test-taking skills, and rewarding students for developing a good objective test mentality.

A Confrontation?

The problem of an objective test approach to education is not easily solved. Objective testing has become institutionalized, and it is now a driving force in our educational system. Moreover, most currently available CAI seems designed to contribute to this approach to education.

I suspect that eventually there will be a major confrontation between the forces that support standardized testing, objective testing, and objective-oriented CAI, and those who feel that this represents a major threat to education. Currently I side with the latter group.

Appendix M

On Being a Technology Advisor

Author's Note: This editorial written by David Moursund was first published in the October 1989 issue of The Computing Teacher.

This editorial is intended for instructional systems technology (IST) coordinators at the school building, district, or higher level. In the "good old days" we called such people computer coordinators. The IST designation emphasizes that the focus is much broader than just computers.

This editorial focuses on just one aspect of your job—that of being a instructional systems technology-oriented technical advisor to your boss. If you are a school building IST coordinator, your boss may be a principal or an assistant principal. If your are a school district IST coordinator, your boss may be a superintendent or an assistant superintendent. In either case your boss is an administrator with a wide range of responsibilities. Your boss makes decisions that strongly affect instructional use of instructional systems technologies in your school or district.

Here is a little evaluation form that you can fill out. If you have a good working relationship with your boss, then you can have your boss fill out a modified version of the form. (For example, where is says "My boss has " change it to "I have .") In any case, the results can serve as a fruitful basis for assessing the current situation and/or for discussion with your boss and with others.

The Instructional Systems Technology Advice Instrument contains six statements that are to be answered on a five-point scale. On this scale (1) indicated "Strongly Disagree" and (5) indicated "Strongly Agree."

On Being a Technology Advisor Instructional Systems Technology Advice Instrument

1. My boss has a good knowledge of instructional systems technologies. This knowledge is quite adequate for making appropriate decisions concerning allocation of resources and in making other decisions that affect their use in schools.

   (Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

2. My boss works closely with other administrators who have a good knowledge of instructional systems technologies. This close working relationship provides my boss with the advice needed to make appropriate decisions concerning allocation of resources and in making other decisions that affect their use in schools.

   (Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

3. My boss has an instructional systems technology advisory committee and meets regularly with this committee. This committee is broadly representative of the people both within and outside the school system who are most interested in and affected by decisions related to school use of instructional systems technologies.

   (Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

4. My boss relies quite heavily on the advice of instructional systems technology hardware and software sales representatives when making decisions about

instructional systems technology hardware and software acquisitions and the use of such facilities.

(Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

5. My boss relies heavily on other people (not mentioned above) who are not educators when making decisions about instructional systems technologies. (Examples of such people include electronic data processing staff in the school district business data processing office, professional programmers, secretaries who are computer users, and children who are well versed in using computers.)

(Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

6. My boss relies heavily on my advice in all decision situations involving instructional systems technologies. We meet regularly together and I am quite satisfied with our working relationship and how my advice is received.

(Strongly Disagree) 1 2 3 4 5 (Strongly Agree)

You can decide for yourself the profile of answers that would be most appropriate to your situation. If you have your boss fill out a similar evaluation instrument, the two of you can then compare your perceptions. If you or the two of you have given a number of low ratings on items 1, 2, 3, and 6, and high ratings on items 4 and 5, the chances are that this is a bad situation.

There are two key issues.

1. Instructional systems technology is changing very rapidly. It is even difficult for a person who devotes full time to this field to remain reasonably well informed.
2. Instructional systems technology has the potential to have a massive impact on education. It is a major (potential) change agent in our schools.

If you are happy with the your boss' sources of information, that's great. If you are unhappy, you need to chart a course of action.

The first step is a needs assessment, and you have done that. Give it a little more thought. What are the strengths and weaknesses of your boss' sources of IST advice? What can you personally do to reinforce the strengths and to decrease reliance on the less appropriate sources?

Next, set some short-term and some longer-term goals. Remember, you are working to change the way a person functions. People resist change!

Next, begin to develop a plan of action. Remember, education is political. On average, school administrators are far more politically astute than IST coordinators. But you are quite capable of learning to play the political game. Also, it is easy to take advantage of your boss' political astuteness.

We will give just one example to illustrate the point. Suppose that your boss relies on very few sources of advice except IST hardware and software vendors. This is a very bad situation and can easily lead to major inappropriate decisions. Moreover, it is a situation that is politically untenable once it comes to light.

Thus, you need to engineer having someone hint to your boss that he/she is in an untenable situation. Such a suggestion can come from a school board member, a higher-level school administrator, a couple of parents, a local business leader, a spokesperson for the teacher's union, or a variety of other people. In any case, the hint should be accompanied by a suggestion that an IST Advisory Committee is needed. This committee should play a major role in all IST-related decisions being made in the school or school district.

Don't expect immediate success. Keep up the pressure on your boss. More than likely you will win out in the end. Good luck!

Appendix N

Effective Inservice for Computers in Education

Author's Note: This editorial written by David Moursund was first published in the November 1989 issue of The Computing Teacher.

Inservice education is a major vehicle for increasing the appropriate and effective use of computers in schools. But most inservice education is not nearly as effective as it could be.

Over the past four years, I have spent a great deal of time studying and practicing in the area of design and implementation of effective computer inservice. I have taught two graduate courses on effective inservice, done a number of inservices on effective inservice, and written a book on the topic. Now, I believe I have a clear understanding of some of the major problems that computer inservicers face and what can be done to overcome these problems.

Here are a few overriding ideas:

1. Inservice is a vehicle for school improvement and change. (Not all change leads to improvement.) If a school is to improve, the teachers and administrators must make a concerted commitment to work together towards the desired improvement.
2. The inservice designer, coordinator, and/or facilitator is a key change agent in our school system. This person has important leadership responsibilities.
3. There are many research-based models for school improvement; many of these are heavily dependent on inservice.
4. A great deal is known about effective inservice practices; systematic use of these practices will greatly improve inservice.
5. But education is political, and reality dictates many non-optimal choices in the design and conduct of inservice.

The most common type of inservice is a group inservice, with a number of people coming together for one or more sessions. A highly effective and often cost effective alternative is the one-on-one or very small group inservice.

The list given below is a conceptual model for the key design features of a really good group inservice.

1. Needs assessment based on possible participants.

An inservice facilitator can base a needs assessment on introspection, knowledge of educational research on school improvement, talking to colleagues, careful study of district educational goals, long-range planning that the school or district has conducted, and so on. But it is very important that substantial attention be paid to the potential participants in the inservice. Information can be gathered from potential participants by one-on-one interviews, groups interviews, questionnaires, and so on. Often use of a combination of these is desirable.

2. Design the inservice; prepare and/or obtain handout materials; make arrangements for time, place, refreshments, credits, and so on.

A substantial amount of work needs to be done before the inservice begins. Pay careful attention to details. Lay out a timeline that has plenty of flexibility. For example, it may take months to arrange for district or university credit for participants in an inservice. It may take a month or more to obtain software and print materials.

3. **Recruit actual participants. Gather baseline data on participants and their students, school computer facilities, and so on, so that you will be able to do summative evaluation after the inservice ends.**

Often it takes a substantial "sales effort" to recruit participants. Every effort should be made to have a critical mass of teachers from each school that is participating. In general, it is far better to reach a large number of teachers in a small number of schools, rather than vice versa. Be aware that the research strongly supports having school administrators participate in the inservices for teachers.

If your evaluation is going to include measures of change in participants and/or their students, quite a bit of baseline data will need to be gathered before the inservice begins and/or almost simultaneously with the first inservice session.

4. **Hold an inservice session and do formative evaluation as appropriate.**

The research strongly supports the assertion that "one-shot" inservices are seldom effective. However, sometimes the choice boils down to having a one-shot inservice or no inservice. If the inservice is two or more sessions in length, it should include relatively formal formative evaluation that provide information for mid-course corrections.

5. **Participants implement ideas in their classrooms; they have support from peers and/or inservice staff.**

The underlying goal of the inservice is to improve the education being received by the students of the participants in the inservice. This means that the participants must appropriately and effectively implement some of the ideas covered in the inservice. In a multiple session inservice, implementation should occur between sessions. Support for this implementation should be provided. It might be provided by a combination of peer coaching and inservice facilitator coaching.

6. **Repeat 4 and 5 as needed.**

It is highly desirable that an inservice have multiple sessions, with time for implementation between sessions. Remember, the goal is to have participants implement the new ideas that they are learning. For most educators, the type of changes we are talking about require multiple inservices and a substantial amount of follow up support.

7. **Do summative evaluation at the end of the inservices on perceived quality and effectiveness.**

Ask participants what they think and feel about the content, quality, and effectiveness of the inservice. Be aware that such evaluation tends to encourage participants to think about what they have learned in the inservice; it encourages them to apply what they have learned.

8. **Provide short and long-term follow up support of participants as participants implement what they have learned.**

Participant support can come from colleagues, from the inservice provider, or perhaps from other people in the school district. (One reason for strongly encouraging participation of school-level administrators is that they can provide follow up support and encouragement.) The key idea is that participants continue to receive support and encouragement to implement and to continue to use the new ideas that they have learned.

9. **Do short and long-term evaluation of residual effect of the inservice on the participants.**

The key idea is that you want some "residual effect" to continue to persist long after the inservice is completed. The mere process of attempting to measure it is apt to contribute to it. (If participants know that you will be visiting their classrooms a few weeks after the inservice is over in order to see what they have been doing, they are apt to be doing something.)

10. Do short and long-term evaluation of the effect of the inservice on the students of the participants.

This is only possible if baseline data has been gathered before inservice participants begin to implement ideas they are learning in the inservice. By and large, it requires a relatively carefully designed and implemented research effort to adequately determine short-term and long-term effects on students. Relatively few inservice projects make any significant effort to do so.

Think about the computer education group inservices that you help to design and facilitate. Do you follow the ideas in the above list? If not, chances are that there is substantial room for improvement in these inservices.

Appendix O

Qualitative and Quantitative Assessment of Students

Author's Note: This editorial written by David Moursund was first published in the March 1990 issue of The Computing Teacher. *At that time it was titled, One Consequence of the Information Age. The title has been changed here to better suggest the content of the editorial.*

According to John Naisbitt, in the United States the Information Age officially began in 1956.[1]

Outwardly, the United States appeared to be a thriving industrial economy, yet a little-noticed symbolic milestone heralded the end of an era. In 1956, for the first time in American history, white-collar workers in technical, managerial, and clerical positions outnumbered blue-collar workers. Industrial America was giving way to a new society, where, for the first time in history, most of us worked with information rather than producing goods.

While the milestone was passed in 1956, the trend has not stopped. The number of blue-collar jobs in the United States is now less than 20% of the total and is still declining. The magnitude of the change is not unlike the change that occurred as the United States moved from being an Agricultural Age society to being an Industrial Age society. When the Revolutionary War began in the United States in 1776, about 90% of the population lived on farms. Now, about 3% of the work force are classified as farmers.

It is relatively easy to count the number of workers in different categories. It is more difficult to understand the meaning of the changes that have occurred. And it is still more difficult to design an educational system to appropriately meet the needs of people in this changed society.

Part of the difficulty lies in the widespread acceptance of certain models of success. To a large extent, we have come to believe that almost everything worth measuring in school can be measured by a multiple choice test. Moreover, we tend to believe that such "objective" tests are reliable and valid measures of what we are attempting to accomplish in school.

There is an interesting parallel here with what is going on in educational research. A large amount of current educational research can be divided into two categories—quantitative and qualitative. The quantitative researchers are the number crunchers. They measure things and carry out statistical computations on the results. The qualitative researchers draw on careful observational techniques from anthropology. They observe, and they provide "rich" descriptions of what they observe.

A quantitative study may gather data on hundreds of subjects and report results as being significant at the .05 level. A qualitative study may gather data from one or just a few subjects, and it will report results in a long, carefully written document.

Interestingly, both methodologies of research can be applied to almost any educational problem. Moreover, it appears that the pendulum is swinging from quantitative research to qualitative research. More and more educational researchers are acknowledging that many educational research problems are better addressed by qualitative methodology or by a careful blend of the two methodologies.

Teachers have long known that both quantitative and qualitative methodology is needed in the assessment of students. They realize that there is a substantial difference between the numbers in a gradebook and the mental model they have of a student. However, the (Industrial Age) educational system has forced teachers to place the greater emphasis on the quantitative model of student performance. It is a rare teacher who adds more than a few sentences to the student grade report at the end of a term. Generally, the permanent record is merely a number or a letter—quantitative data that may be completely divorced from the mental model that the teacher has formed of a student and the student's performance.

Now we are at the essence of a major educational problem. Computers make it even easier to gather quantitative data and to represent a student as a set of numbers. A computerized gradebook may help in this process. Indeed, the computer system may even include a list of "canned" comments that a teacher can select and have added to the grade report. These are stock phrases that give an illusion that the teacher is providing individualized, carefully-thought-out comments about a student.

Some proponents of computer assisted instruction point to the record-keeping abilities of the computer and the ideas of computer managed instruction. In computer assisted instruction, we can keep detailed records on every keystroke the student makes, and we can subject this data to careful statistical analysis.

The problem is, we have very good and increasing evidence that this quantitative model of education is inappropriate and inadequate. If the model is inadequate, no matter how good we get at quantitative measurements of student performance, we will not succeed in making major improvements in education through this approach.

There is an excellent discussion of quantitative and qualitative educational research in the October 1989 issue of *Educational Researcher*.[2] It is written from the point of view of a researcher in the year 2009 looking back to 1989 as a time of major change in educational research methodology. The article suggests that researchers will come to understand that both methodologies are quite important and in most instances need to be used in conjunction with each other.

Let's assume that this prediction is correct and that the same holds for the "mini research" that each teacher conducts on each student each term. Then the research report that a teacher writes on a student (the end-of-term grade report) should be based on a carefully crafted combination of quantitative and qualitative methodologies. The report should be a blend of succinct "statistical" statements and "rich" description.

This gives teachers and teacher unions a target to shoot at. *The size of classes and the demands placed on teachers must allow teachers to use both quantitative and qualitative methodologies in determining and reporting student progress.* This is a simple statement with far reaching implications. For example, it suggests that teachers need careful training in both quantitative and qualitative methodologies and in the reporting of results obtained from use of these methodologies. It means that if we want to permanently store student records, we need facilities that store both quantitative and qualitative reports. It means that we need to educate school board members, taxpayers, parents, and legislators on the merits of this more broad-based perspective.

The task is formidable. The general public has been educated to expect reports such as, "The SAT scores for the school district were up two points over last year." Such reports do not question the meaning or value of the SAT. They do not reflect that perhaps teachers have been "teaching to the test" or that students have had increased access to computer software specifically designed to improve SAT scores. They do not reflect the large and increasing percentage of students who do not take the SAT test (they have long since dropped out of school) and for whom such measures are totally inappropriate.

What can we do about this? Here is a little piece of an answer. You, the individual teacher, can begin to experiment with qualitative methodologies. Select a single class or a few students in a class. Begin to create a "rich" description for the students you select. If you want to use a computerized gradebook, select one that allows you to type in substantial comments on a daily basis. At the end of the term, compare your qualitative description with the quantitative description. Begin to think about the similarities and differences between the results. Pay careful attention to how this different methodology can help you be more effective. You will likely discover that this new perspective on student evaluation is making you into a better teacher!

[1]John Naisbitt. (1982). *Megatrends: Ten New Directions Transforming Our Lives.* New York: Warner Books, Inc.

[2]N. L. Gage. (1989). The paradigm wars and the aftermath: A historical sketch of research on teaching since 1989. *Educational Researcher, 18*(7), 4-10.

Appendix P

The Information Age: Evolutionary and Revolutionary Change

This editorial by David Moursund was first published in the April 1990 issue of The Computing Teacher.

During the past year we have seen a major change in the nature of the governmental structure of Eastern Europe and the USSR. Undoubtedly these changes will be analyzed for many years to come. Why did these changes come about? Were they all due to one man, Gorbachev, addressing an economic crisis in the USSR?

In this editorial I argue that the Information Age is directly responsible for the political changes mentioned above. Then I explore the analogy between this and possible changes in our educational system.

The Information Age is often defined in terms of a change in the nature of employment. In the US in 1956, the number of people holding white collar jobs first exceeded the number holding blue collar jobs. We were witnessing a major decline in industrial production jobs and a major increase in service jobs. Many of these service jobs involved working with information, in jobs such as teacher, nurse, bank clerk, and computer programmer.

However, this change in the dominant classification of jobs fails to capture the essence of what was going on. The Information Age is characterized by a number of simultaneous and continuing changes that are having a major cumulative effect. A few of them are:

1. Transportation. Jet airplanes and more air travel; more efficient transportation of goods via land, sea, and air.
2. Telecommunication. Rapidly improving telecommunication making use of microwave, fiber optic, satellite, and more conventional systems. Explosive growth of the television industry.
3. Computers. Massive improvement in our ability to store, process, and retrieve information; more cost effective process control devices.
4. Automation. A continuing gradual increase in the productivity of blue-collar workers.
5. Education. More people receiving a higher level of education.
6. Research in science and technology. There have been major breakthroughs in understanding key ideas in science and applying this knowledge to produce goods and services.
7. Worldwide economic competition. This is facilitated by improvements in transportation and communication.

The Information Age changes are not affecting all parts of the world equally. Changes have occurred more rapidly in Western Europe than in Eastern Europe and the USSR. The people living in Eastern Europe gradually became aware that there were major differences between there life style and the life style of those in Western Europe. The leaders of the Eastern bloc countries attempted to build a wall that would keep out such information. The wall severely restricted travel, and that certainly helped keep out information. A few hundred years ago, that might would have succeeded. In those days information flowed mainly via people either personally carrying the message (oral tradition) or via written letters.

Unfortunately for the Eastern Europe leaders, it was necessary to keep open some holes in the wall, and the wall could not keep out radio and television signals. Holes had to be kept open in order for Eastern Europe scientists to build on knowledge being developed outside their area. A certain amount of transportation and interchange of goods was necessary for economic reasons.

Perhaps even more important, a country that wants to prosper in the Information Age needs a highly educated citizenry. Education must stress problem solving and other higher-order cognitive skills. Such education breeds people who challenge the system and who resist oppression.

To summarize, the factors underlying the Information Age let to a gradual change in the nature of life in Western Europe and major other parts of the globe, and a gradual increase of knowledge about this among people in Eastern Europe. The gradually increasing pressures on the economies and governments of Eastern Europe and the USSR could not withstand the onslaught.

Now compare this with our educational system. The question is, do we have a similar situation shaping up in our educational system? We have the transportation and communication that allow key constituencies in our educational system to be aware of what others are doing and the outcomes. Thus, the issue is whether there are major stakeholders who can see other, similar stakeholders, who are "getting a better deal." Here are some examples of things to look for:

1. Students in one region—city, county, state, or nation—getting a far superior education.
2. Teachers in one region enjoying a far superior set of working conditions such as level of respect, pay, work load, and the general nature of their students.
3. The members of one ethnic group being able to provide their children with a better education than is available to the children of another ethnic group.
4. The private sector in one region having access to a better trained pool of workers than the private sector in another region.
5. A nation and its government competing better economically and politically due to an overall superior educational system.

When big differences exist and the stakeholders become aware of them, there are several possible results. First, the stakeholders can say, "I am aware of these differences. I am not bothered by them. I am satisfied with the current state of affairs." Or, they might say, "That is not right. Something should be done about it."

In the latter case, we have a power struggle. Does the stakeholder who says, "That is not right" have the power to do anything about it? If the overall system is sufficiently free and open, inequities lead to gradual, evolutionary change. If the system is oppressive to key stakeholders, the inevitable result will be a revolutionary change.

In my opinion, our educational system is poised on the brink. Massive change agents such as distance education, computer-assisted learning, transportation of students, and corporation-run schools could lead to massive, relatively rapid, revolutionary changes in our current system.

Alternatively, our current system may change fast enough to accommodate the revolutionary pressures. There are a few signs that it is attempting to do so. Some states are developing voucher systems that give students a choice of what schools they will attend. Some states are passing legislation that facilitates increased use of distance education and of computer-assisted learning. Some regions are increasing the pay of teachers and attempting to improve their work conditions.

The outcomes are in doubt. It will be interesting to see what happens.

Appendix Q

Looking at Ten Years of Educational Computing: Running Hard Just to Stay Even

Author's Note: This brief article was written for a special Tenth Anniversary publication of the Educational Computing Consortium of Ohio, published in fall 1990.

Most people who are currently involved in educational computing seem unaware that the field of educational computing is far more than 10 years old. They do not know, for example, that the Association for Computing Machinery was established in 1947, that a number of high school students and teachers were using FORTRAN in 1958, that the Association for Educational Data Systems was founded in 1962, and that Logo was developed in the late 1960s, about the time that BASIC was becoming strongly entrenched in schools.

For most people, educational computing began when microcomputers began to become somewhat available in schools, which was about ten years ago. These 10 years have been exciting and sobering. During this time computers have profoundly affected the lives of many teachers and students. Computers have received rave reviews and lots of support as a vehicle for substantially improving our schools.

The reality, of course, is that computers have had only a modest impact on our schools. During the past decade the potential for computers to have a major impact on education has continued to grow quite rapidly. The potential for computers in education may well be growing faster than we are making progress toward realizing the potential. This potential has been expanded by computers becoming many more times cost effective than they were at the beginning of the decade, by the development of more and better software, by a huge amount of computer-oriented staff development for inservice teachers and of computer education for preservice teachers, and by the development of huge amount of instructional materials.

With all of the progress, you might think that the field of educational use of computers in schools would be well established, making major contributions to improving education. Unfortunately, that assumption is based on a static view of education. An education that was good enough and appropriate for 1980 is not good enough and appropriate for 1990. Our educational system must make major changes over a decade in order to just stay as good as it was.

The field of computers in education has shown us how hard it is for education to change enough in a decade to just stay even. The structure of our schools is not appropriate for a rapidly changing society. The teaching load is too high, the time allowed for teachers to learn new ideas and to interact with each other is too little. The funding for innovation and for new equipment is far too small.

Over the long run, I expect that the struggle schools are having in adequately dealing with computer technology will provide us with major evidence on how to restructure our educational system. Our educational system needs to provide major amounts of time and significant incentives for teachers to learn new ideas and to learn to integrate them into the curriculum. Teaching loads need to be decreased. Our educational system needs to have much better provisions for acquiring the materials, hardware, software, laboratory equipment, library materials, and other components of an effective educational system.

Right now our schools are running as fast as they can in these areas, but are falling behind.

This last decade of progress in the area of computers in education has actually been one of running very fast but ending up further from the target. Without major changes in the structure of schools, we can expect the same for the next decade!

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