Dedicated to

Lucy Poole
Bernard’s mother, 97 years young, February 15, 2006

Anne Giorgio
Marilyn Giorgio-Poole’s mother, 91 years young, December 23, 2006

Marilyn Giorgio-Poole, PhD
Bernard’s wife, whose dogged determination to complete a task once begun has inspired him in the completion of many a tough task, including this book

Zsolt Poole
Marilyn and Bernard’s son, who is busy completing a significant task of his own just now as he nears completion of his Masters’ degree in Electrical Engineering at the University of Pittsburgh

John McIlvain, Willa Sky Bacon
and every teacher and administrator who looks to the 21st Century
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Teaching In The Computerized Classroom, 7th edition
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Introduction

Thus education forms the common mind;
Just as the twig is bent, the tree's inclined.
Alexander Pope (1688-1744)

I have hope that society may be reformed,
when I see how much education may be reformed.
Gottfried Wilhelm von Leibnitz (1646-1716)

THE CHALLENGE OF CHANGE

The audience for this 7th edition of Education for an Information Age is the pre-service/in-service K-12 teacher. The primary goal of the text is to help you incorporate instructional technologies in general, and computer-based technologies in particular, into the curriculum. A secondary goal is to help you become the most effective educator you can be. The computer, along with the expanding range of associated technology, is just one of many tools and techniques that can improve the learning environment that you provide for your students.

To this latter extent, the book cannot be taken in isolation. The ideas and skills presented form part of the continuum of learning and experience related to your profession that began when you were yourself a student K-12, continues during your college studies as an Education major, and ultimately bears fruit in your role as a teacher in the classroom.

The Need for Change

There has been a great deal of hype about the computer as a tool for teaching. Perhaps it is in the nature of the profession, but teachers are more skeptical than most about the advent of yet another fad, yet another experimental methodology, yet another pedagogical imposter destined to come and go like so many others. But change is something we have to accept. "The most fundamental element in education is change. This is implicit in its very definition. All learning requires change. Education as a 'process' must 'proceed' or move ahead. Stagnation is therefore directly and fundamentally opposed to education. It is the basic evil for education." These words of Philip Phenix are a rallying cry to those associated with children’s education, calling on them to accept the inevitability of change and embrace it judiciously as the need arises.

Change, in and of itself, is not usually welcomed with open arms. As Machiavelli observed: "It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage, than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old institutions and merely lukewarm defenders in those who would gain by the new ones."1

People in general are resistant to change, even when it is for the better. There is a certain inertia built into time-tested ways of doing things. "If it ain't broke don't fix it," as they say;

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1 Niccolo di Bernardo Machiavelli, 1469-1527
and the fact is that time-tested methodologies—chalk and talk, competition, rote learning, regimentation—have been successful until relatively recently in achieving the goal of turning out at least an educated elite from our schools.

But with the collapse of agriculture and of industry as the primary providers of people's bread and butter (robots will be doing most all of the agricultural and industrial work in the future), today's increasingly service-oriented, information-based societies are waking up to the fact that an educated elite will put food on only a small number of plates on a nation's table. Today, we have to ensure that everyone has a realistic opportunity to develop the intellectual skills required to prosper in an information age.

To this end education needs help. We continue to be A Nation At Risk (National Committee on Excellence in Education, 1984). A growing number of young people graduating from our public schools are ill-prepared to find gainful employment in today’s workplace, let alone tomorrow’s. Already, the majority of well-paying jobs require higher order intellectual skills—strong communication skills, information gathering and analysis skills, interpersonal skills, learning skills, creative skills, and critical-thinking skills (SCANS, 1991).

This is not to deny the progress that American education has made over the years. In fact there is cause for great optimism, as pointed out in the report Workplace Competencies: The Need to Improve Literacy and Employment Readiness (Information Services Office, 1990). A century ago, one was considered literate if one could sign one's name. Today, almost all young adults can do that. Fifty years ago, the criterion for literacy was the ability to read at fourth grade level. Today, 95% of young adults meet this criterion. Twenty-five years ago, one was deemed literate, by the War on Poverty standards, if one could read at the eighth grade level. Today, 80% of young adults read at that level. These are indeed grounds for optimism.

But young adult preparedness for a productive and prosperous life requires more than merely the ability to read at an eighth grade level. To quote from the above-mentioned Workplace Competencies report:

The requirements [for America's work force] are likely upward, at least in many important sectors of the economy and in particular employers' needs. The present technological environment has enlarged some workers' responsibilities. The lines between workers and supervisors and managers blur as "work teams" or "quality circles" are used to raise creativity and productivity. The team members put their heads together and solve problems. The members can do each other's jobs. They must be flexible. And they have to deal with print, often in more complex forms than before. In short, the requirements are rising in some areas that are highly visible to employers and to observers of the economy in general, and it is against these growing demands and expectations that the adequacy of preparation for the entering work force must be viewed.

**Teachers Make a Difference**

The challenge is enormous, but we must hold on to the conviction that each one of us, in making our contribution, can make a difference. There indeed is the source of joy in
Introduction

teaching—the act, day by day, of "putting a spark" in young minds. As Anatole France observed, "If there is some good inflammable stuff, it will catch fire."

This text examines all aspects of computer-based technologies as part of the set of tools in a teacher's methodological toolbox. In the pages that follow, you will have the opportunity to learn about computing in general and about computer-based education in particular. The computer is clearly not the whole solution to the challenge of broadening and deepening the base of appropriately-educated citizens; but it may be part of the solution. How significant a part that is depends on you, the teacher.

Teachers, like most everyone else, sometimes find technology off-putting, even scary. The most effective way to overcome fear is to face it. So the ideal accompaniment to the study of the material in this book is hands-on experience with, and review of, a wide range of applications of value in K-12 teaching and learning. It is assumed that students reading this book will have such an opportunity in the School of Education where they are being prepared to teach in tomorrow’s schools.

OBJECTIVES OF THE TEXT

1. To encourage the use of computers in the classroom by removing the mystery that surrounds the technology

Many teachers resist using computers in their classrooms because they are intimidated by the technology. For this reason, an objective of Education for an Information Age is to take away the mystery that often surrounds these machines by emphasizing their use as tools. You will read about the hardware and software of digital computers at a level that will help you understand what makes them tick.

You will also be introduced to several of the most important communications and audio-visual innovations, such as networks, scanners, smart boards, overhead projection systems, interactive video, and multimedia systems in general, that have come to depend on computer technology.

2. To apply the principles of educational theory to the use of computers in the classroom

Another objective of this text is to help teachers at all levels of education, but especially K-12, to discern quality educational software among the plethora of packages available today. In pursuit of this objective, you will review educational theory (at various points throughout the text, pulling everything together in chapter 14) and apply it to the use of computers in education.

Over thousands of years, philosophers and educationists have expounded upon various theories of learning, from mental discipline to constructivism. You will be expected to apply these theories in your professional life. As a result of reviewing learning theory, you will be more informed in your selection of computer-based materials for classroom use, ensuring that they meet the objectives of the learning experience which you plan to provide for your students.
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Notice that knowledge of learning theory, accompanied by a deep understanding of how children learn, precedes and underpins any use of technology in the classroom. Just because the makers of courseware indicate that the learning outcomes for students using their software will be thus and so does not mean that those outcomes will occur. Children, unsupervised, get the darnest unexpected benefits, or lack of benefits, from using courseware, as the case study at the end of Chapter 6 shows. For this reason, as Caftori (1994) puts it so well: "The teacher should come 'bundled' with the software."

Children need teachers. There are those in the teaching profession who fear that computers in schools will bring about a reduction in the number of teachers in the workforce. As this book, however, will show, the opposite is more likely to be true because computers will promote individualized instruction. Individuals have unique needs that are difficult to diagnose. Tomorrow's teachers, working closely with fewer students than ever, will be given the opportunity to help each of their students select from a rich variety of multimedia material to sew together a tailor-made learning experience.

3. To provide opportunities for hands-on computer experience

It is beyond the scope of this book to profile in more than a superficial fashion specific courseware for teaching and learning. Here we are concerned with concepts, rather than keystrokes because keystrokes are essentially ephemeral; concepts endure.

Hands-on experience with computing is nonetheless important, and to this end the author has worked with colleagues to prepare sets of tutorials—for Microsoft’s Office 2000, Office XP, Office 2003, and Office 2007 suites of productivity software. These tutorials are designed to help the pre-service and in-service teacher learn, step-by-step, the various classroom-relevant functions of these general purpose software tools.

The author has also set up a home page on the Internet (http://www.pitt.edu/~edindex) with links to Web sites worldwide that are sources of information (lesson plans, teaching materials, workshops, books, and other items of interest) for teachers and students K-12 who are interested in finding out more about almost any subject under the sun.

Ideally, you will also have at hand a wide selection of special purpose learning software (also called “courseware”) designed for use in the learning process. This selection might include the graphical organizer Inspiration along with the version designed for young users called Kidspiration. It might also include the drawing and presentation program KidPix, also for young users, or the more sophisticated PowerPoint. These programs are but the tip of the iceberg that represents the plethora of courseware items designed for all age groups and for every subject in the K-12 curriculum.

It will be a valuable learning experience to review the myriad examples of computer-based learning systems that are available today. Free, shareware, and demo versions of much of this software can be downloaded and reviewed prior to use in the classroom.

At http://www.pitt.edu/~poole/download.html you will find links to several on-line companies that offer courseware either free of charge or at steeply discounted prices.
Introduction

By the time you have completed your journey through this text, you will have strengthened your commitment to keeping abreast of developments in educational computing. You also will have laid a solid foundation for the classroom of the future in which you will recognize and pursue opportunities to integrate computer-based technologies into the curriculum.

Every hour you spend physically and mentally interacting with the computer will increase your familiarity with the technology and your competence in its use. Indeed, you will come to marvel at its applicability to the learning process. Most important of all, you will empathize with your students' enthusiasm for computer-based systems and become caught up in that enthusiasm yourself.

4. To help teachers understand the effect that computing and communications is having on the society in which their students live

Our times are variously referred to as The Computer Age, The Information Age, and The Age of Technology. There is no doubt that the last fifty to sixty years have brought about a dramatic change in the very infrastructure of almost every society on the planet, some more than others. Technological innovation has permeated so many areas of our lives—in the home, in medical care, in travel, in communications, in government, in finance, in industry, in recreational activities—and, of course, in schools.

Children growing up in these societies have a different frame of reference from those of previous generations. Marshall McLuhan pointed out that "The medium is the message": the very technological transformation that is taking place will have an impact on the culture that adopts it, and those most likely to experience the acculturation at its deepest level will be the children of the culture.

As teachers, we must at least keep an open mind on the ever-changing world of our students' experience, and if we can integrate the changes into our own experience, so much the better.

This is not to say that teachers should shift gears into the era of classroom computerization just for the sake of it, just because it is there. There must be a rationale, a conviction born of research and experience, which makes the adjustment part of their general predisposition to provide the best possible educational opportunity for the children in their care. For this reason, the book sets out, in chapter 1, by addressing the important questions: Is learning enhanced by the appropriate incorporation of technology, especially computer-based technology, into the curriculum? And are students disadvantaged when they are denied access to computer-based systems for teaching and learning?

NEW IN THE 7th EDITION

This 7th edition of EDUCATION FOR AN INFORMATION AGE continues the collaboration with Elizabeth Sky-McIlvain. Elizabeth brings a wealth of both technological
Introduction

and pedagogical experience which has greatly improved the currency and relevance of those sections of the book (chapters 5 through 8 and chapter 10) that she has taken under her wing.

John Evans of Boise State University has also joined the team and accepted responsibility for Chapters 1 through 4. John’s strong background in Computer Science, along with his ability to clearly explain technical concepts, greatly strengthens the accuracy and currency of the content of these early chapters in the book.

Other changes in this edition, as in any new edition, are included to bring the text up to date so that it reflects the current state of the art in technology and the current state of practice in technology-integrated education. This state of the art is in a constant state of flux, more now than ever before, which is why we will try to make it no more than a year or two between each new edition of the book.

CONCLUSION

Most teachers choose the teaching profession because they are excited by the challenge of helping children learn. These teachers are sustained in the profession by the joy that comes from seeing the light of newfound knowledge gleaming in a child's eyes. If this book, by helping you to discover the value of computers in an educational setting, empowers you to more effectively meet the challenge of education in today’s increasingly technology-infused schools, then it will have succeeded in its overall goal—to help you become a better teacher.

None of this will happen overnight, so you will need a good dose of patience and perseverance during the initial stages of your journey towards becoming a computer literate teacher. But you will find that the rewards of successful integration of computers into the curriculum and into your classroom administration will be incalculable. You are going to be glad you set out on this adventure.

It is still not unusual to find just one computer in a classroom. Sometimes it sits there gathering dust. The children would love to get their hands on it, but the teacher perhaps does not know where to beg in allowing its use in a pedagogically powerful way, perhaps even fearing that uncontrolled use will result in its being damaged or destroyed!

If you are one of those many teachers who recognize the need to start using computers but have hesitated till now to take the first step, know that every step you take will lessen any fear you may feel and will increase your potential as an effective teacher in this Information Age. If this book helps you take these steps, all the effort that has gone into its creation will have been worthwhile.

Bernard John Poole, Elizabeth Sky-McIlvain, John Evans, Yvonne Singer, January 11, 2009.
Chapter 1: Technology Use in Teaching and Learning: What’s the Return on Investment?

Chapter One

Technology Use in Teaching and Learning: What's the Return on Investment?

The greatest wrong, the greatest treason,
Is to do the right thing for the wrong reason.

T.S. Elliot (1888-1965)

Murder in the Cathedral

In time I will utter the truth of my plight.
I will remember the people who helped me.
I cannot do this without help.

Autistic child

(communicating using computer-based technology)

LEARNING OUTCOMES

This chapter reviews research and other published reports that examine the effectiveness of computer-based teaching and learning. The objective is to justify the expense in time and money incurred by schools in the acquisition of instructional technologies and requisite user skills.

Teachers who have successfully incorporated the computer and related technologies into the teaching and learning process have come to the conclusion that it can add significant value to teaching and learning when it is integrated thoughtfully by the teachers, with strong commitment and support from school administrators at all levels. Absent this thoughtful integration and strong commitment and support from administration, investment in computer-based technologies for teaching and learning will yield little or no return.

The material covered in this chapter, coupled with the evidence that teachers gather from their own experience using the computer in the classroom, is of great value because it should provide a rationale for requests made to foundations and local, state, or federal government agencies for grants and other support of technology-assisted learning. To quote Bailey (1992): "[The] response to the question: 'What does research say about the impact of technology on education?' has a direct bearing on how school board members, parents, teachers, and students view and support technology."

Teachers are not just teachers; they are fund-raisers, too. They need to learn how to write proposals requesting financial support for their work in the classroom. Chapter 12 will cover the whole process of writing grant proposals, which will be successful depending on whether or not the proposal convinces the providers of financial support that they are likely to get a worthwhile return on their investment. Hence the need to be familiar with studies that support the effective incorporation of instructional technologies into the curriculum.

This chapter thus will examine the following topics:
Chapter 1: Technology Use in Teaching and Learning: What’s the Return on Investment?

• Sources for Research and Other Findings
• What General Conclusions Can Be Drawn from the Research?
• In What Ways Does Digital (Computer-Based) Technology Enhance Teaching and Learning?
  • When used effectively, the computer is a valuable tool in support of learning
  • When used effectively, the computer is a valuable tool in support of teaching
  • When used effectively, the computer is a valuable tool in support of children’s socialization
  • Computers and related technologies enable children with disabilities to integrate successfully into the educational system
  • Software that is well-designed to support learning enables a teacher to duplicate excellence
• Summary of research outcomes
  • The Three R’s
  • Science
  • Social studies
  • Computer-assisted collaborative learning
  • One-to-one computing
• Why Is It Taking So Long for Schools to Change?
• Computer-Integrated Teaching and Learning: The Ten Pillars of Success

This is by no means an exhaustive list of those instructional technology application areas that have been researched in any depth. But it is likely to be of interest to those preparing for, or already engaged in, teaching K-12 because they address broad-based topics that relate to key areas of responsibility within the educational process.

INTRODUCTION

The goal of this book is to help teachers integrate computer-based technology into the educational curriculum in such a way that it improves learning. The significant investment of time and effort, not to mention money, in pursuit of this goal is a relatively recent phenomenon in schools. Computers first started appearing in K-12 classrooms in the late 1970s. Since then, huge sums of money have been spent to provide schools with computers and computer-related equipment. Teachers worldwide, but especially in the wealthier nations, are trained in the use of instructional technologies for teaching and learning.

Such an investment presupposes a consensus that the myriad applications of this technology currently flooding the educational marketplace are an improvement on tried and true teaching methodologies. Is this the case? Dickson (1984) quotes Joseph Weizenbaum, Professor of Computer Science at the Massachusetts Institute of Technology, who cautions: "Everyone agrees that in principle computers are powerful, but too often teachers ... find they are following a common scenario: First you get the hardware, then you get the software, then you train the teachers, and only then do you start trying to work out what you are going to do with it all."

The International Society for Technology in Education (ISTE), in 1998 published an online report titled: "Our Educational System Must Produce Technology Capable Kids" (ISTE, 1998). These
days, however, one hardly needs an educational system as such in order to produce technology-capable kids. Children are now technology-capable, for the most part, by the time they reach adolescence without much help from schools. They use information technology for "problem-solving and decision-making" to a much more sophisticated degree than most of their parents. They are "creative and effective users of productivity tools" such as word processors and, increasingly, of graphics, spreadsheet, presentation and database software, too. They use e-mail, instant messaging, and text messaging as a matter of course, communicating in writing far more extensively than most adults.

The issue of raising children who are technology-capable is rapidly becoming a non-issue for schools as technology becomes an integral part of the infrastructure of modern life, starting in the home. By the time children go to school, many are already more technology-savvy than their teachers. Most, if not all, children in the wealthier countries of the world soon will come to school with a wireless computer/communications device small enough to fit easily into their backpack and which, using cellular technology, will give them 24/7 access to all the online learning services they might need.

Close to two million K-12 teachers in the U.S. will retire by the year 2010 (ISTE, 1998). This is an extraordinary number when one considers that there are only a little over three million U.S. teachers in the total workforce! This represents a great opportunity for effecting change in schools, an opportunity which ISTE addresses very well in another report: "Will New Teachers Be Prepared to Teach in a Digital Age?" (Milken Exchange/ISTE, 1999,1). In her foreword to the report, Cheryl Lemke, Executive Director of The Milken Exchange, puts it well when she says: "Today's students live in a global, knowledge-based age, and they deserve teachers whose practice embraces the best that technology can bring to learning."

**SOURCES FOR RESEARCH AND OTHER FINDINGS**

What is the research that indicates that computer use in schools is effective? There are many resources available to help answer this question. For example, Apple Computer, Inc. (1990) made available in electronic form an extensive review of research done between 1980 and 1989 to assess the impact of computers on K-12 education. The project was managed by Dr. Lyn Allen of Apple Computer, Inc. and edited by Dr. Dan Gibbs, former Superintendent of the Fort Myers, Florida, school district. The review does a good job of directly or indirectly summarizing the findings of several hundred published studies.

The findings of the Apple-sponsored project, summarized in this chapter, are to a large extent corroborated by similar reviews (OTA, 1988, 1994, Kinnaman, 1990) carried out by more manifestly disinterested parties.

David Dwyer (1990, 1994), Director of the Apple Classrooms of Tomorrow (ACOT) program and a recognized expert in the application of technology for learning, has led a longitudinal research study, begun in 1985, which has collected and analyzed data from technology-infused classrooms. The objective has been to “investigate how routine use of technology by teachers and students would affect teaching and learning.”
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The Milken Family Foundation Education Technology Initiative, formerly The Milken Exchange, conducted extensive research to evaluate technology’s value for teaching and learning. The report, published in 1999, examined learning technology issues in K-12 education, in particular whether or not technology use is effective in improving learning.

A more recent report entitled: “Effects of Using Instructional Technology in Elementary and Secondary Schools: What Controlled Evaluation Studies Say,” (Kulik, 2003) has reviewed research studies of technology applications in elementary and secondary schools published between 1990 and 1999. Kulik examined these studies as to their findings in the areas of reading, writing, math and science instruction. In general, the conclusion of the SRI study is that “the literature is too uneven for sweeping conclusions about the effectiveness of instructional technology.” However, solid conclusions may be drawn about specific aspects of technology’s value as a tool for learning.

This is particularly true of writing, a skill fundamental to the whole learning process. Writing, like speech, is a medium of communication, and effective communication is key to so many life skills. If technology can help improve students’ writing abilities, then technology has an important place in schools. The studies examined by Kulik found benefits of technology in other areas of K-12 education as outlined later in this chapter.

Furthermore, articles are published week after week, in journals and magazines devoted to sharing the results of ongoing research, along with anecdotal accounts of successful application of technology in the classroom. One of the more significant publications is the Journal of Research on Technology in Education, published quarterly by ISTE.

A study sponsored by The Center for Research in Educational Policy (CREP) at the University of Memphis (Lowther et al., 2003) compares the relative benefits of different degrees of technology infusion in 5th, 6th, and 7th grade classrooms. The study sets out to determine whether a 1:1 computer-to-student ratio (using laptops made available to the students 24 hours a day, 7 days a week) would promote superior learning in the areas of writing and problem-solving as compared to control classrooms where there were 5+ computers per class. The results from this study, along with a research synthesis of the implementation and effects of one-to-one computing initiatives (Bonifaz, Zucker, 2004, and Penuel, 2005, 2006), are included in this chapter in the summary of research outcomes.

WHAT GENERAL CONCLUSIONS CAN WE DRAW FROM THE RESEARCH?

When John Vincent Atanasoff invented the electronic digital computer in 1939, he did so to meet an educational need: to free his doctoral students in the Physics department at Iowa State University from the tedium of doing math so that they could concentrate their academic time and effort on problems associated more directly with physics (Mollenhoff, 1985). But it was not until the late 1970s that computers began appearing in K-12 classrooms, and not until the late 1980s that they were present in sufficient numbers to make any kind of appreciable difference.

"The mark of fertility in a science," according to Jean Piaget (1926), "is its capacity for practical application." Can the computer as a tool for teaching and learning be practically applied in schools? What evidence is there that computer-based teaching tools make a difference in the
learning process? Is this merely another pedagogical fad destined to come and go like so many others? How well have these systems been designed? Do they reflect the wisdom of educational philosophies born of centuries of cumulative educational experience?

Has the research been done to answer these important questions? The answer is Yes—to some extent at least; though much more research needs to be done (Riel, 1994). Milken Exchange/ISTE (1999, 2) reports that "Research on the impact of technology on learning is in its infancy, though we are beginning to see solid work emerge."

The many studies that have been done indicate that specific aspects of the learning process can be significantly augmented by computer-based educational technologies. However, as Selfe (1992) points out, computer-based teaching and learning presents a whole new set of pedagogical and logistical realities that will need to be thought through before technology can be integrated into the curriculum in the best possible way.

Kinnaman (1990) and Tierney (1992), too, remind us that much of the research that has been done might have been more impressive if it had been conducted in other than traditional learning settings. Connected to online resources such as the World Wide Web, the computer puts the student in a learning environment that spills over outside of the classroom into everyday life. For a growing number of students, the classroom—the locus for learning—is not necessarily in school. Ready access to online and offline computer-based technologies provides opportunities for learning more or less any time and anywhere. So we do need to study what learning occurs in non-traditional settings.

Judy Salpeter (1998), Editor-in-Chief of Technology and Learning magazine, interviewed eight of the leading research experts in this field of educational applications of technology. Whether or not the use of technology in education is effective, she notes, is "an issue that's far too complex to yield a simple answer." We have to decide "what types of technology, with which types of students, under what conditions, lead to best results." It will be instructive to examine what her interviewees had to say.

For example, from her interview with Henry Jay Becker, sociologist and professor of Education at the University of California, Irvine, it is clear that technology works well as a tool in constructivist learning environments where the learner, alone or as a member of a team, is able to delve into larger, more complex projects. Becker's review of the research nonetheless leads him to recognize the proven value of technology when applied to the learning of basic skills in traditional settings.

Larry Cuban, professor at Stanford University and a former high school teacher, is critical of those who advocate technology use in schools primarily for the purpose of preparing students for gainful employment in a computerized world. For Cuban, this is a classic example of "doing the right thing for the wrong reason." It leads to schools investing heavily in technology infrastructure without significantly, if at all, changing the way schooling is done. Cuban, however, like Becker, recognizes that technology can affect teaching by promoting a constructivist approach. Indeed he is optimistic in this regard.

Salpeter also interviewed David Dwyer, vice president for advanced learning technologies at Computer Curriculum Corporation (CCC). Prior to joining CCC, he directed the Apple Classrooms of Tomorrow (ACOT) research program—a program praised by Cuban for readiness
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to "think outside the box" of traditional schooling when infusing learning environments with computer-based technologies. The outcomes of the ACOT program demonstrated the benefits of computer use for both traditional and non-traditional learning modalities. Indeed, quantitative studies conducted at sites sponsored by the ACOT program showed, time and again, that "it takes about 30 percent less time to learn the same things with help from the computer."

Another of Salpeter's interviewees was Cheryl Lemke of The Milken Exchange on Educational Technology. This organization has as its mission to examine and report on learning technology issues in K-12 education. Lemke points out that educational research into the effectiveness of technology use in education should be asking better questions, such as "What is the set of conditions for technologies in schools that optimize learning?" Her point is that learning can be "energized through the creation and effective use of technology and communications."

The Milken Exchange conducted public opinion polls about technology use in education which indicated that Americans were worried that schools in the United States were moving too slowly in implementing technology, that schools which were not well-equipped put their students at a disadvantage over those that were, and that they were willing to have their own taxes dedicated to funding investments in education.

Summarizing the outcomes of the study conducted by The Milken Exchange (Milken Exchange/ISTE, 1999, 2), Lemke concluded that, under the right set of circumstances:

- technology and communications can accelerate, enrich and deepen basic skills;
- technology can be a great tool for motivating and engaging students;
- technology in schools can be a wonderful link between academics and emerging practices in a host of professional fields, so to speak taking science out of the laboratory and out into the field of every day life;
- technology can dramatically increase the viability of students in the work force, the skills acquired making them more employable and professionally productive;
- technology can strengthen teaching, providing teachers with a powerful learning tool which also promotes individualized instruction;
- technology can be a catalyst for change in schools by prompting teachers to rethink how they do education by rethinking their whole role in the classroom when they need no longer think of themselves as the provider of information content, but rather as the facilitator of learning in an already information-rich online environment.

Barbara Means, vice president of the Policy Division and a member of the Center for Technology in Learning at SRI International in California, cautions school districts against using standardized tests to measure the effectiveness of a technology program, if only because of the difficulty of interpreting results without a rigorous research endeavor. In this, she is echoing the views of Raymond Rose, also interviewed for Technology and Learning magazine, who criticizes the return on investment (ROI) mentality of politicians who want to see outcomes measured by standardized test scores. Instead, Means recommends assessing students by measuring outcomes against the question: "What is it we want students to know and be able to do?" In other words,
while objective standards are all well and good, unless technology is specifically used to promote learning of the standards, its use cannot be measured against them. Rose, director of the Educational Technology Lab at The Concord Consortium in Concord, Massachusetts, further believes that we should be using technology to enable learning that could not happen otherwise. Such learning might include something as simple as using technology tools for graphing data or conducting dangerous science experiments using computer simulations. What added value does technology bring to the classroom? That is the question that needs to be asked and answered when assessing technology's impact in education.

The next of Judy Salpeter's interviewees, Saul Rockman, has been involved in instructional technology research for many years. In study after study, he says, there have been "substantive changes in teaching and learning when technology is used in appropriate ways." This includes infusion of technology into a learning environment such that it is so pervasive that it becomes a part of the school culture. The ultimate example of this would be where a school provides laptop computers for every student in the school, along with wireless access to online services. Teachers and students are thus able to operate within the context of a reality where neither the classroom, nor the learning process, is any longer confined within the four walls of any single location. The outcome: a substantial reduction in lecturing and an increase in project-based instruction and cooperative learning amongst students. However, Rockman emphasizes the importance of the teacher's role even in a technology-rich environment such as this. Students need feedback and guidance in all aspects of learning, especially early on, whether technology is used or not.

Rockman also notes the increase in parent involvement in education where communications technology is used to close the gap between the home and school. But above all, Rockman pleads for teachers to be given time and support to integrate the technology into their teaching, a theme to which we will return again and again in this book.

The last of Salpeter's interviews was with Jay Sivin-Kachala, vice president of Interactive Systems Design, Inc., whose "Report on the Effectiveness of Technology on Schools, '90-'97" reviewed 219 research studies to assess technology's impact on learning in all K-12 subject areas and age groups. This report was also reviewed for The Milken Exchange/ISTE study (1999,2) which analyzed "the five largest scale studies of educational technology to-date." In his interview, Sivin-Kachala brushes aside the question as to whether or not we should be using technology in schools, but rather reiterates the findings of Rose and Means that we have to ask "Under what conditions is technology valuable?" Specifically, Sivin-Kachala's review of the research showed interactive video, CD-ROM storybooks, computer-based drill and practice and tutorials to be powerful instructional tools. Higher order thinking skills were also shown to be taught better with computers, all other things being equal. This latter finding was predicated on the use of the right assessment tools—performance-based assessment, not simply standardized tests. Students using computer-based tools designed to develop higher order thinking skills were able to score as well as non computer-using groups in standardized tests. Computer-based learning thus added value to the normal classroom instruction.

A common theme emerging from all these studies is that teaching is key. The better the teacher is trained in the use of technology for instruction, the more effective the computer-based learning will be. Sivin-Kachala concludes his interview by saying that "it's not just the technology that
determines the quality of a learning situation; it's the whole mix – what the class does before they use technology, what the teacher does while students use technology, how the students are grouped, how prepared students are for technology-based learning experiences, and what the class groups or individual students do as a follow-up to using the technology." All these variables need to be considered and are controlled by the well-trained and well-prepared technology-using teacher.

IN WHAT WAYS DOES DIGITAL (COMPUTER-BASED) TECHNOLOGY ENHANCE TEACHING AND LEARNING?

The following sections discuss ways in which the suitably-integrated computer can contribute to quality outcomes in the classroom. Useful further discussion would be for you to brainstorm on this subject to come up with other ways in which such outcomes are enabled by computer-based teaching and learning.

*When used effectively, the computer is a valuable tool in support of learning*

During the course of this text, we will examine various specific types of computer-based learning systems that take different approaches to helping children assimilate knowledge. These include drill and practice programs, tutorials, simulations, technology-facilitated collaborative learning, distance learning, integrated learning systems (ILS), and Internet-based learning in hypermedia and multimedia environments.

Networking—the linking of computers over communications lines—is opening up an ever-expanding world of learning opportunities for students, teachers and administrators alike. More and more states have established networks to facilitate communication between school administrations and a central state administrative office. States are also realizing the benefits of size-related clout when negotiating with vendors such as online database or telecommunications providers for statewide information services. This is true, for example, in Ohio where the Department of Education has negotiated with computer software and hardware vendors on behalf of the state's public school and university systems.

Nationwide, schools can now take advantage of federally-funded communications highways—the so-called National Information Infrastructure (NII)—which are encouraging data sharing as never before with the potential for significant individual information gain. The Internet, in particular, is an ever-expanding data resource with increasing significance at all levels of education. Not only can students tap the Internet for encyclopedic content from A to Z; they also can use the Internet to communicate with other students, as well as with teachers and other subject-related "experts" both locally and around the globe. We will return to this theme at various points throughout this text, but especially in chapter 8 where the focus will be on distance learning and the Internet.

The best school districts are making this resource available to students at every age level—appropriately supervised, of course. Netiva Caftori (1994) advises, based on her research, that "software systems should come bundled with the teacher." Students, even at the college level, often need the teacher to help them manage the learning process and get the most out of learning opportunities, with the goal of fostering a structured, goal-oriented, quality education. After all,
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as Barbara Foster (2000) put it so well, "The teacher's goal is always to design learning experiences that will help the students succeed."

This new online, interactive modality for learning is leading to interesting changes in the way education is done (Riel, 1994). This is a subject that will be discussed further at various points throughout the text. Lemke (2000) notes that digital media are a "reflection of our society—they are instantaneous, interactive, up-to-date, just in time, often visually stimulating and accessible round the clock." Digital media also are a fast-paced highway for new discovery in all areas of knowledge. Dedicated students at the highest levels and in all academic disciplines are patiently pursuing their investigations of current understanding, from fractals to foreign policy, quicksands to quickfreeze, shrimps to Shakespeare, video compression to volleyball, and so forth.

This reality of our modern world inexorably must be reflected in our schools if those schools are not to become anachronistic. Lemke therefore advocates that schools should "create a learning culture which actively engages students in relevant, meaningful work within the study of the vast knowledge base that is constantly being reshaped by emerging technologies."

When used effectively, the computer is a valuable tool in support of teaching

Technology-aware teachers use the computer to prepare and produce printed (hard copy) and screen-displayed (soft copy) teaching and learning materials of all kinds, whether word processed documents, presentation materials, still-image and video graphics, or database records.

Preparation of syllabi, schedules, and classroom materials can be more efficiently and professionally produced using the computer. This is especially the case when, as is more and more likely the case, the printer is a high quality device such as a laser printer. It is anachronistic today to use the typewriter for this kind of work. Having said that, it is not a bad idea to know where you can get access to a typewriter on the rare occasion when you might need one!

Word processors, spreadsheets, databases, and presentation software, as well as special-purpose classroom administration systems now available free of charge on the web (at locations such as http://www.schoolonline.com), can streamline data presentation, record-keeping, and availability of school-related information. All this, however, is predicated on the teacher being well-organized in the first place. It is a well-demonstrated axiom that the computer is only as organized as the person using it!

Savvy teachers also are taking advantage of the Web to provide learning modules and other resources which virtually extend, beyond the classroom, their influence over their students' education. We will discuss these issues further in chapters 7 and 8 of the text which discuss networks (chapter 7) and online systems such as the Internet (chapter 8).

Students are the beneficiaries of teacher use of computer-based technology to assist in classroom instruction. They are more likely to be given necessary, valuable, timely and accurate feedback on their progress, along with pointers (hyperlinks or hotlinks) to locations "out there" where they can discover or construct the information that will serve them all their lives.

When used effectively, the computer is a valuable tool in support of children’s socialization

This can come about not simply by exposing children to computer programs that help them learn about themselves and their world, but also by fostering cooperative or collaborative learning. The
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computer is a tool to share. It is fascinating to observe small groups of children gathered at the computer working together on a writing project where all the work is captured electronically. Each student brings his or her own special abilities to the project. Students unhesitatingly call on their teammates to help them with knowledge or skills that they lack. This is collaborative learning at its best. Howard Gardner (2000) acknowledges that his theory of multiple intelligences has particular relevance in a classroom where the special talents of each individual student are allowed to flourish in this way.

*Computers and related technologies enable children with disabilities to integrate successfully into the educational system*

Chapter 13 (Computers, Education, and Society) discusses some of the enabling systems that have been developed over the last ten to twenty years. These systems make it possible for the physically-challenged to function independently in society. Advances in enabling technology have accelerated since the early 1990s to the point where today children with almost any physical disability can be provided with computer-based systems which will allow them to communicate, do research, collaborate with their peers, learn, and contribute as effectively as other children in and out of the classroom setting.

Thompson (1996) goes further in suggesting, based on his personal experience working with children with disabilities, that such children actually have an academic advantage because their disability ensures that they have early access to computer-based education. In Pennsylvania, for example, it is mandated by state law that children who are defined as disabled have a guaranteed sufficiency of support, including whatever technology is available to help them enjoy the same educational benefits as non-disabled children.

*Software that is well-designed to support learning enables a teacher to duplicate excellence*

There are more and more examples of educational software recognized as pedagogically sound. Many teachers are now using productivity software—word processors, database management systems, spreadsheets, communications software, drawing tools, along with other administrative tools for handling grades, attendance, and so forth—to manage the whole process of teaching and learning. They are creating excellent learning materials that, because they are produced in electronic (digital) form, can easily be shared with their colleagues everywhere. Well-designed and integrated materials such as these support successful learning environments for children, thus duplicating excellence when they are made available to all.

Taking this idea one step further, in chapter 11 we will discuss authoring systems. These products help take the creation of learning systems out of the hands of technologists and into the hands of the teachers themselves. Innovative teachers thus are able to share their expertise—duplicating excellence—by developing lessons (and tutorials, learning modules, simulations, and so forth) that incorporate an ever-expanding array of computer-based teaching and learning aids.

At one time or another all teachers have those magic moments when they touch the hearts and minds of their students and thus, as the saying goes, "touch the future." But even the best teachers in the world find it difficult to operate at their best all the time. We all have our professional ups and downs. As long as we have to rely solely on our own devices to manage the educational process, we inevitably subject our students to something of a roller-coaster educational
experience. Thoughtful integration of appropriate computer-based learning can take some of this pressure off teachers, enabling them to provide, from their own stock of teaching experience as well as that of others, consistently excellent learning experiences both in their classrooms and in their students' homes.

In recent years we have seen a truly amazing growth in web-based services for educators where dedicated teachers, education organizations, local, state and federal government entities, and even companies, have invested time and effort (and money) in developing rich portals or gateways to learning resources that are, for the most part, freely available for teachers and students to use. One of the oldest of these organizations is ERIC (Education Resource International Clearinghouse). But ERIC is no longer (as of December 2003) supported by the US Department of Education. Fortunately, other organizations are taking up the slack. A selection of these may be reviewed in the EdIndex—a web resource maintained by the authors of this book with links to dozens of such websites.

SUMMARY OF RESEARCH OUTCOMES

The Three R's

Reading, Writing and Arithmetic, since the early 19th century at least, have been hailed as the basic ingredients of education for literacy\(^1\) at the elementary level. The vast majority of children are born equipped with the intellectual prerequisites for literacy—the ability to read, write and handle enough math to cope with the demands of the contemporary world. Ensuring that every child has the opportunity to become literate is still largely the role of primary schools worldwide.

What evidence is there that computer technology can help children learn to read, write, and do math?

As you review the conclusions that follow, bear in mind that learning outcomes often complement each other. For example, when computer-using students "displayed more subject/verb agreement" in their writing than other students who did not use the computer, this may well be because the computer-using students "reread and revised their compositions more frequently than a control group using pen and paper." Also bear in mind that, in general, students are inclined to think of technology-based education as "fun" because it is "hands on" and relevant to their world (Thode, 1988).

The computer is a tool in the hands of both the student and the teacher. The effectiveness of that tool depends entirely on the skills that each brings to the learning process. Students are no more passive soakers-up of knowledge than teachers are robotized imparters of knowledge. As educationists from Dewey on have emphasized, children learn best when they are actively engaged in, and in control of, their own education (Harris, 1991). Constructivism also emphasizes the dual role of teacher and student in maintaining a "zone of proximal development" (Vygotsky, 1962) which is defined by Harris (1991) as "the area between what a learner can do independently

\(^1\) "Literacy" is here used in the sense of "possession of education" (Random House, 1991). It should be remembered that in these waning years of the 20th century there are still countries where the universal right to even an elementary education is a novel and barely implemented phenomenon.
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(mastery level) and what can be accomplished with the assistance of a competent adult or peer (instructional level)."

The outcomes of the computer-based systems for teaching and learning described in the following pages likewise are not automatic; they are the result of a collaboration between the teacher, the student, and the designers of the technology with the goal of preparing an environment for effective learning.

Reading One of the most celebrated computer-based systems for teaching early reading and writing has been that developed by Dr. John Henry Martin in cooperation with IBM. This system, called Writing To Read™, has been in use since 1982 and has been thoroughly evaluated both by the Educational Testing Service (ETS), commissioned by IBM, and by other independent researchers.

We are interested in how effective the Writing to Read program has been in improving on more traditional methodologies for helping children of kindergarten and first grade age to learn to read and write. If rapid progress and joy in learning are a measure of a program's effectiveness, then Writing to Read has been very successful. The program is in operation in schools across the United States, and one cannot but be impressed by the philosophy and pedagogy that has guided its development. In fact, one is reminded of the methodologies employed in the Montessori schools where children "explode" into writing after learning the letters and the sounds associated with those letters (Standing, 1962). However, Montessori’s children do not need computers to discover reading by themselves once they are ready to make the leap from writing the letters associated with the sounds that make up language. So, the question remains: Do the computers in the Writing To Read program make any significant difference?

Studies such as Murphy (1984) note that the program has been more effective in teaching writing than reading, putting Writing to Read students significantly ahead of non-Writing to Read students in terms of writing skills. However, the results also showed that eventually the non-Writing to Read students caught up with their Writing to Read counterparts. The program gave participants a jump start on basic literacy skills, but neither the advantage gained over non-Writing to Read students nor the rate of progress were sustained after the program was completed. Indeed, a year later the Writing to Read students' writing skills had declined slightly while the non-Writing to Read students continued to improve.

Olson (1987) provides a further caveat. Teachers involved with Writing to Read classes tended to have their students spend more time reading and writing than had been the practice in previous years. So any conclusions about the effectiveness of the program as compared with other well-researched alternatives remain tentative.

A major question mark about Writing To Read relates to cost-effectiveness. Slavin (1990) indicates that first year costs per lab were high (and more than three times the manufacturer's list price). The reason for the discrepancy is that the list price did not cover all expenses involved with the system. By contrast, research has shown that reading programs sponsored by the U.S. Department of Education (Alphaphonics, MECCA, TALK, MARC, and INSTRUCT) that cost just a few hundred dollars per class, have been at least as effective as Writing To Read.
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Larter (1987) corroborates the conclusions of the research into the *Writing To Read* program when she notes that using computers did not significantly improve students' reading in either the first, third, or sixth grades. Some researchers have found that students of all ages have difficulty reading and writing online. One reason for this may be that computer-based reading and writing requires users to learn to cope with online texts, screens, and file directories instead of the printed page and tables of contents—what Selfe (1992) calls a "multi-layered literacy."

Certainly, good old-fashioned books take some beating when it comes to reading in general. Ergonomically-speaking, there is a lot to be said for reading a book curled up in an armchair in front of a warm fire or lying out in the sun on a lawn, a deck, or a beach. Scrolling through the text on a notebook computer does not have the same carefree, relaxed feel to it; it's almost as if the machinery might get in the way of one's enjoyment and interfere with one's concentration. The goal of any learning environment, however, is to foster learning, and the data confirm that the *Writing to Read* program achieves this goal. If money is no object, and the learning is enjoyable, too, then so much the better.

The jury is thus still out on the effectiveness of using computers to help children learn to read. Roblyer (1988), in his review of the research from 1980-1987, found that the use of computer applications for reading resulted in "educationally significant effects," and that "tutorials" seem more effective than other kinds of tools in reading." As for so many aspects of using computers in teaching and learning, success may depend on a shift in paradigms. Products such as the *Waterford Early Reading Program*, that use CD-ROM technology to bring a book to life with text, full color illustrations and sound, need to be studied further. However, as Sivin-Kachala (1998) found in his large-scale review of research studies from 1990-1997, the capability of giving students rich, individualized reading instruction using CD-ROM storybooks is likely to be beneficial since a teacher cannot, under the circumstances, "have that sort of one-on-one time with every student."

Teachers who use optical disc technology such as CD-ROM are enthusiastic about a technology that "has made reading exciting," as one kindergarten teacher at York Central School in Retsoff, New York, put it. "The children feel empowered, and we're definitely seeing an improvement in reading skills" (Electronic Learning, 1992). Of course, anecdotal evidence is easy to come by and therefore should be taken with a grain of salt. But when positive anecdotal evidence abounds it reinforces the outcome of more rigorous research.

**Writing** Unlike reading, there is a good deal of research confirming the benefits of student use of computers for writing assignments. The conclusions listed below are consistent whether the research focused on learning disabled students or regular students.

- Students using the computer and word processor for writing assignments generally

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1 Ergonomics—also called Human Factors Engineering—is the study of the interfacing (interaction) between people and machines.
2 Software that interactively walks the student through a reading exercise.
3 Compact Disc-Read Only Memory: Optical disc-based medium, now replaced for the most part by Digital Video Disc (DVD), it enables users to more easily work with full-color, interactive graphics and sound along with text. The technology will be discussed further in chapters 2 and 8.
felt more positive about the writing instruction they received and about their own writing skills (Kurth, 1987,1, 2; Roblyer, 1988; Klenow, 1991);
improved the quality and fluency of their writing (Burnett, 1984; Muldrow, 1986; Bigley, 1986; Cirello, 1986; Larter, 1987; Klenow, 1991; Lowther, 2003);
were more self-motivated with regard to the subject-matter of their writing (Rosegrant, 1985);
were motivated to achieve literacy because of the computer's visual, auditory, and physical support (Rosegrant, 1985);

improved in literacy because they were encouraged to read what they had written (Rosegrant, 1985; Lowther, 2003);

found software useful for tutoring, writing theory, getting ideas, organizing thoughts, composing, providing feedback, and communicating with others (Frase, 1987; Lowther, 2003);

wanted to write more (Roblyer, 1988; Lowther, 2003).

• With regard to revising their work, students using the computer and word processor for writing assignments

were more self-motivated to revise drafts and spent more time on the process (Pearson, 1986; Souviney, 1986; Hague, 1986; Hawisher, 1986; Muldrow, 1986; Kurth, 1987,1; Katz, 1987; Dalton, 1987; Eastman, 1988, 1989; Klenow, 1991; Lowther, 2003);

produced higher quality revisions than revisions completed using pen and paper (Daiute, 1986; Muldrow, 1986; Kurth, 1987,1; Kurth, 1987,3; Eastman, 1989; Lowther, 2003);

when using the computer's readability measure competed to see who would write at the highest grade level and increased grade level from first draft to revised draft which encouraged them to revise their drafts (Hague, 1986);

adapted more easily to composing on a computer when emphasis was put on revising as opposed to advance planning¹ (Lansing, 1984; Lowther, 2003);

read over and revised their compositions more frequently and more readily than a control group using pen and paper (Rust, 1986; Butler-Nalin, 1987; Kurth, 1987,1; Eastman, 1988, 1989; Lowther, 2003);

made revisions that involved an increase in the length of the composition (Daiute, 1986; Rust, 1986; Bigley, 1986; Cirello, 1986; Kurth, 1987,2; Eastman, 1989).

• With regard to the mechanics of writing, students using the computer and word processor for writing assignments

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¹ Students who planned their written work in advance would not need the help of interactive revision as much as those who didn’t plan their work ahead of time.
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more readily developed conceptual abilities since they did not have to physically create the symbols with which they expressed those concepts (Daiute, 1985, 2; Rosegrant, 1985; Souviney, 1986);
composed more fluently than they would have with pencils and pens because of the automatic recopying and printout features of computers (Daiute, 1985, 2; Rust, 1986; Souviney, 1986; Eastman, 1989; Klenow, 1991; Lowther, 2003);
found that triple-spaced copy made editing easier (Rust, 1986);

felt that keyboarding did not interfere with writing\(^1\) (Muldrow, 1986; Cheever, 1987);
prepared computer drafts that contained fewer words than pen and paper drafts when composing time was limited to 15 minutes, and longer drafts than with pen and paper when more time was allowed (Daiute, 1986);
were more concerned with the aesthetic quality of their text—layout, appearance, and so forth (Daiute, 1985, 2);
preferred the word processor over pen and paper for writing (Burnett, 1984; Larter, 1987; Klenow, 1991);
produced significantly enhanced science-related documents through the use of the word processor (O'Brien, 1986).

• With regard to the reduction of errors in writing, students using the computer and word processor for writing assignments
showed the most dramatic gains in reducing grammar, punctuation and capitalization errors, and in displaying more subject/verb agreement when they initially demonstrated the lowest ability (Muldrow, 1986; Cheever, 1987; Dalton, 1987);
overlooked fewer errors than when using pen and paper (Daiute, 1986; Klenow, 1991);
made fewer grammar, punctuation and capitalization errors (Cheever, 1987; Lowther, 2003);
displayed more subject/verb agreement than those who did not use the computer (Cheever, 1987).

• With regard to effects not directly related to writing, students using the computer and word processor for writing assignments
may more easily have made the difficult transition from speech to writing (Daiute, 1985, 2);
may more easily have developed self-awareness because of the interactive capacities of a computer (Daiute, 1985, 2);
may have found the computer to be a catalyst in the development of writing skills as adolescents (Curtiss, 1984; Pearson, 1986; Cirello, 1986);

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\(^1\) This conflicts with Selfe's (1992) caveat about "multi-layered literacy" discussed earlier in the chapter.
Using prompting programs to help students compose As Daiute (1985,3) observed, in some schools students have been given the opportunity to use the computer and word processor in conjunction with a prompting program such as Writing Process Workshop (from Educational Activities), or Success With Writing (from Scholastic). These programs are designed to stimulate interaction between the students and their writing.

Students using the computer and word processor in conjunction with a prompting program:

- made more interactive revisions than when using only the word processor especially if they were beginning writers of all ages (Daiute, 1985,3; Daiute, 1986);
- increased their level of reading and rereading their written work (Daiute, 1985,3).

Caveats re: computer use for writing The following research findings remind us that no methodology, no tool, is suited to all situations, and that sometimes the methodology or tool can create or reveal new, unanticipated problems.

- Children of seven years of age or younger may lack the cognitive skills necessary to socialize and collaborate effectively, in writing or otherwise; the writer's age, level of cognitive development, and composing style is critical to how the computer tool is used (Daiute, 1985; Daiute, 1985,2);
- Students working collaboratively will not find collaboration effective for all writing tasks, and should work independently on some writing tasks in order to assure maturation of the writing process (Daiute, 1985);
- The computer is less useful if the hardware or software design is complicated; all computers should ideally be of the same brand and model so as to facilitate group instruction and interaction (Daiute, 1985,2; Frase, 1987; Eastman, 1988);
- Computer writing needs to be integrated with the use of other traditional writing and drawing tools (Daiute, 1985,2);
- Some students found using the keyboard and working with text on line inhibited their writing ability (Curtiss, 1984; Dalton, 1987; Eastman, 1988, 1989; Selfe, 1992);
- Some students neglected planning when using the word processor (Dalton, 1987)\(^1\);
- There needs to be an adequate number of computers for students to work simultaneously and individually (Eastman, 1988; Lowther, 2003);
- Pedagogical styles will need to change to accommodate the use of computers (Daiute, 1985,2; Eastman, 1988, 1989; Tierney, 1992; Lowther, 2003);
- Sixth grade students using the word processor did not necessarily produce better quality writing than those using pencil and paper (Larter, 1987);

\(^1\) Perhaps because revisions were so much easier to make—which is a problem, since planning is always important.
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A few researchers found the computer made practically no difference as regard many aspects of the writing process (Lansing, 1984; Strickland, 1987; Kurth, 1987,1; Roblyer, 1988);

Viewing written work on a computer screen does not appear to help the writing process—hard copy may be the preferred medium for review of written work (Lansing, 1984).

**Arithmetic and problem-solving** Let us now review the research conclusions regarding the effectiveness of computer use in teaching and learning math and problem-solving.

- eighth grade students who used simulation and higher order thinking software showed gains in math scores of up to 15 weeks above grade level as measured by the National Assessment of Educational Progress (NAEP) (Wenglinsky, 1998);
- eighth grade students whose teachers received professional development on computers showed gains of in math scores of up to 13 weeks above grade level as measured by NAEP (Wenglinsky, 1998);
- showed math achievement gains that were significantly greater than the control groups who did not use the computer (Foley, 1984; Roblyer, 1988; Fletcher, 1990, Wenglinsky, 1998);
- spent 50% of all computer time learning programming skills (problem-solving) at the high school level (Becker, 1987);
- were more likely to be helped in basic math and language skills if they were lower-ability students; higher ability students benefited in terms of higher cognitive skills such as problem-solving and programming (Ayoubi, 1985; Samson, 1986; Becker, 1987; Thode, 1988);
- improved problem-solving skills when using Logo as a platform for programming (Spence, 1987, Roblyer, 1988);
- learned concepts such as fractions and binary operations of fractions, graphing, and algebraic precedence conventions significantly more effectively when provided with computer-based experiences in addition to teacher-directed activities as opposed to students who received only teacher-directed activities (Marty, 1985; Al-Ghamdi, 1987; Ball, 1988, Wenglinsky, 1998);
- scored significantly higher on measures of their ability to transfer skills learned with the aid of the computer to other areas of mathematics (Al-Ghamdi, 1987; OTA, 1988).

**Caveats re: computer use for learning math and problem-solving** Joseph Weizenbaum, professor at the Massachusetts Institute of Technology, points out that there is "no more evidence that [problem-solving in the form of computer programming] is good for the mind than Latin is, as sometimes claimed" (Spence, 1987). Other researchers found that students using computers for math and problem-solving

- were not affected as to their attitudes towards math or computers (Foley, 1984, Marty, 1985);
- were not affected with regard to class attendance (Foley, 1984);
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were as likely to find math and computer programming equally difficult (OTA, 1988);

Harold Wenglinsky's 1998 national study of technology's impact on mathematics achievement further found that eighth-grade students who used technology to play learning games and develop higher order thinking performed only 3 to 5 weeks ahead of students who did not use technology (Wenglinsky, 1998). He also found that fourth- and eighth-grade students who use drill and practice software performed worse on NAEP than students who did not use drill and practice technology (Wenglinsky, 1998).

Science In the science classroom, students interacting with computers running simulations of experiments enjoyed a more effective learning experience than students watching a demonstration accompanied by teacher-student interaction. Simulated or real experimentation seems to provide the benefit of involvement—a characteristic of quality learning so ardently advocated by Thomas Edison. "The most important method of education," Edison once remarked, "always has consisted of that in which the pupils were urged to actual performance."

Here is some of the feedback from research into computer-integrated science education. Students who used the computer in the science classroom:

achieved more from computer-based laboratory activities and/or computer simulations than students who studied in a conventional learning environment (White, 1984; Shaw, 1985; Roblyer, 1988);

were more likely to benefit than when using computers for learning in other content areas (Roblyer, 1988);

more effectively learned to generate graphs, to identify trends in graphs and to understand the meaning of information presented in graphs developed during experiments than students developing graphs by hand (Linn, 1987);

were more easily able to transfer understanding from one type of physical activity to another when generating graphs during experiments in microcomputer-based laboratories (Linn, 1987; OTA, 1988);

were able to use the computer as an oscilloscope, temperature probe, pressure sensor, light sensor, etc. by connecting sensors and probes to it, thus extending the use of the computer as a laboratory instrument for science studies at a fraction of the cost of the actual instruments (McCarthy, 1992);

gained skills likely to be valuable throughout their lives when learning how to collect, analyze, and interpret data (Rash, 1990);

produced science-related documents that were significantly enhanced through the use of word processing (O'Brien, 1986).

Caveat re: computer use for teaching and learning science Not all researchers came to the same conclusions. Ayoubi (1985) and Choi (1987) found that students who were given the opportunity for computer-based learning of science gained no advantage in computer-simulated experiments over students who conducted the same experiments hands-on, when the students
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were of average ability. It was also noted that students were involved mostly in drill and practice when using software related to the physical sciences (Hegelson, 1988).

Social studies The following are some outcomes of research into the effectiveness of computer use for social studies.

Social studies benefit from the increasingly varied access to computerized databases of appropriate information (Hunter, 1987). Data Base Management Systems (DBMS) simplify access to large volumes of data covering most subjects in the social studies curriculum. The databases are both local and remote, the latter being accessed via communications media such as the telephone system.

Cohen (1987) drew conclusions similar to those of Hunter. Students were given access to electronic information via online databases. As expected, access to information was quicker, and students developed research skills as well as skills related to computer use and telecommunications.

Studies across the curriculum benefit from using the computer to create, store, retrieve and randomly display data. Students are more easily motivated when using the computer for these activities (Ferguson, 1989).

Massialas (1987) found teachers K-8 enthusiastic about the use of computers for social studies, even though the integration of computers into the curriculum proved complex. The introduction of computers may result in the beginning of curriculum change. It is interesting that Massialas also found that computer use led to an increase in social skills.

Teachers from Fourth through Twelfth grade found that interactive videodiscs provided a multimedia environment that simplified the sequencing and presentation of relevant, high-quality visual information as a supplement to traditional social studies lessons (White, 1990). White noted that videodisc technology was most effective when used in conjunction with a microcomputer running software such as HyperCard.

Audio-telecommunications systems such as voice mail promote the bridging of oceans and cultures, increasing students’ global awareness and international understanding (Galvin, 1989). Voice mail cuts across time zones because it allows students to take up a conversation at any time they choose. Conversations can also be duplicated and shared with other users. Diem (1989) reports on video-conferencing technology used to teach students the nature and importance of global interdependence. Chapter 7 will expand on these technologies when discussing the effectiveness of computers and communications (C&C) in the learning process.

The computer is a useful tool (word processing, database management, simulations, tutorials) for learning traditional social studies concepts (Lengel, 1987; OTA, 1988). Budin (1987) identified the following as directions to pursue in the use of computers in teaching social studies.

1. Develop more software that involves students in decision-making in regard to social studies issues, and expects more input from them;

2. Use software that makes more use of graphics to convey subject-matter;
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3. Use technology such as telecommunications to increase students' global understanding;

4. Use the computer to stimulate more social interaction on the part of the students.

Students are learning to be more effective in finding meaning in data because of the ease with which large amounts of data can be displayed graphically using microcomputers (Hinze, 1989).

Caveats re: computer use in social studies Teachers were concerned about the lack of software. They found a lack of correlation between some of the available software and instructional goals. Teachers also considered themselves inadequately prepared to use computers in the social studies classroom (Massialas, 1987).

According to White (1987), incorporation of the computer into social studies education was most effective when teachers were well trained and were prepared to spend extended time to make the computer-based programs work. Success was also associated with cooperation from institutions outside the school who served as partners.

Schug (1988) found that far more teachers had received training than were presently using computers even though most teachers expected to be using them more. This suggests that either the training was inadequate, or that access to computers was too restrictive to warrant incorporating them into the curriculum, or that the available social studies applications were considered unsatisfactory.

Computer-assisted collaborative learning Teachers in all subject areas are discovering that computer-based learning lends itself to collaboration between groups of students. This is especially true when students are encouraged to work together on writing and other language arts assignments. Such students

surpass students in control classrooms on measures of depth of understanding, reflection, and also on standardized reading, language, and vocabulary tests (Scardamalia and Bereiter, 1996; Lowther, 2003);

worked best in small groups of two, three or four students (Daiute, 1985,1; Ayoubi, 1985); were more often girls than boys, suggesting that collaborative work is more successful with girls (Johnson, 1985);

shared more ideas with classmates than those using traditional methods of composition (Daiute, 1985,1; Heap, 1986; Kurth, 1987,1; Klenow, 1991; Lowther, 2003);

appeared to help each other learn appropriate writing techniques (Daiute, 1985,1; Daiute, 1985,2; Eastman, 1988, 1989; Klenow, 1991);

were encouraged to collaborate because it was simpler to add to and arrange common text (Heap, 1986; Muldrow, 1986; Lowther, 2003);

produced a higher level of achievement in terms of mastery and application of factual information as compared with individualistic learning (Johnson, 1985);

had very little interaction with the teacher (Johnson, 1985).
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One-to-one computing Fully effective integration of computer-based technology in the classroom will only happen when every student has access to a personal computer all the time (Zucker, 2005, Penual, 2005, 2006, and Brumfield, 2006).

This is referred to as one-to-one computing.

A growing number of schools, in some cases sponsored at the state level, are purchasing laptop computers for all the students and all the teachers. The idea is that the computer should be as ubiquitous in schools as the textbook—along with the chalkboard, and pen and paper, of course.

For example, the state of Indiana has the ACCESS (Affordable Classroom Computers for Every Secondary Student) program which negotiates discounted computer purchases with computer suppliers and sets them up with the Linux operating system and Open Source software.

Both Linux and Open Source software are free.

“Each computer,” the Indiana Department of Education report (2005) says, “is equipped with a complete MS OFFICE compatible office suite (Star Office 8), networking software, Mozilla's Firefox browser, email if desired (Evolution), photo editing software (GIMP), CMAP – Concept Mapping Software, VNC, and Codeweaver's Crossover Office (WINE).”

“Future installs,” the report states, “will include ITALC software to allow teachers to monitor student workstations, and also Scribus, an open source illustration and layout program. Thousands of other open source programs are available for other purposes.”

The Indiana ACCESS program is a work in progress with long-range one-to-one computing goals.

It seems inevitable that, in time, one-to-one computing in K-12 schools will be ubiquitous and as inexpensive as today’s cell phone. We are still a long way from universal availability of one-to-one computing in schools. It is, however, a goal "devoutly to be wished," as Shakespeare would say.

The potential benefits of one-to-one computing are hard to dispute. Zucker (2005) reports that "Policymakers' goals for laptop programs include increasing economic competitiveness, reducing the inequity in access to computers and information between students from wealthy and poor families, raising student achievement through specific interventions (such as improving students' understanding of algebra through the use of education software), and transforming the quality of instruction.”

The world at large is seeking to embrace one-to-one computing. Nicholas Negroponte’s One Laptop Per Child (OLPC) program, established in 2005, is seminal and serious in its goals. China, Nigeria, and Thailand are already working with the OPLC initiative to provide computers for every single child in their neck of the woods. What a fabulously ambitious—and realizable—goal!

The future in K-12 schools is one-to-one. We are in a period of rapid transformation from one instructional paradigm to another. We teachers MUST be ready for tomorrow’s world in schools.

But let us never forget that a successful K-12 one-to-one computer program requires careful planning, strong leadership at all levels, adequate funding, carefully implemented logistical and technical support, and, above all, ongoing training for teachers, students, and parents.
WHY IS IT TAKING SO LONG FOR SCHOOLS TO CHANGE?

Marcinkiewicz (1994) noted that only about half the teachers in his study were using computers at all for instruction. The U.S. Department of Education National Center for Education Statistics (1999) noted that "relatively few teachers (20%) report feeling well-prepared to integrate technology into classroom instruction." A 2006 survey (Broomfield, 2006) conducted by CDW-G, a reseller of hardware tools to schools and governments, and administered by education research firm Quality Education Data (QED), suggests that the situation has somewhat improved; "81 percent of those surveyed said they used technology for research purposes when preparing lessons, and 79 percent use technology as a teaching tool in the classroom." Moreover, according to the survey, "four out of five teachers indicated that technology is very or somewhat important to teaching. Eighty-eight percent of those surveyed said technology is important to administrative functions such as attendance and grading, while 86 percent agreed it was important to communications with other teachers, administrators, parents, and students."

Yet 55 percent of those surveyed "believe the biggest impediment to effective technology integration is access to computers; 48 percent believe they lack sufficient time to properly integrate technology into lessons; and another 48 percent say district budgets do not allow the level of technology integration they would like to see in their classrooms."

If computers are such a boon to education, why is it that so few teachers have developed curricula that incorporate their use? Here are some perhaps obvious reasons.

Until the waning years of the 20th century, desktop computers were unable to run sophisticated learning programs because they were not powerful enough Early software was very limited in what it could do. If the program used graphics it ran too slowly, and the images were primitive by contemporary standards. If it lacked graphics, animation, or audio-visual interactivity its interest value was diminished significantly.

Still today, with the new millennium upon us, computer technology along with the computing infrastructure to support it is too expensive to justify the purchase of computers in sufficient numbers to make a significant impact in a school. Too few teachers have up-to-date networked computers on their desks. This means that most teachers, whether they like it or not, have to do without them most, if not all, of the time while they are working with students. The same is true of students. In 1988, Bulkeley had already noted that schools that purchase computers are faced with the expense of replacing old machines before they can even think about adding more computers. And in any case, Herb Lin of the National Academy of Sciences observed that "even if there were one computer per classroom, that's less than two minutes per student for a one-hour class" (Borrell, 1992). There is a need for infusion of computer-based learning technology to the point of saturation in the classroom and the home. Computing in the home is reaching this point in economically-advanced nations such as the United States where the online computer is rapidly becoming as ubiquitous as the TV. But in the classroom, even in the United States, many students are provided with few, if any, computers and too often those computers are old.
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Educators are no different than other people; they resist the change made possible by interactive computing Marcinkiewicz (1994) cites Nickerson (1980) who gave five reasons why people who might benefit from interactive computing systems nonetheless balk at using them. First, there is a natural resistance to change. Second, they fear that automation will lead to loss of status. Third, many potential users, teachers included, are ignorant of the potential of computers. Fourth, there is a fear of replacing familiar procedures with unfamiliar ones. And fifth, people like to do things the way they’ve learned to do them and fear the loss of hard-earned skills.

Flexibility should be designed into school schedules Elmer-Dewitt (1991) points out that at most age levels in most schools, the time frame around which lessons are planned is about 40 minutes. But when students work together on a project that uses the computer for research, data analysis and presentation, this time frame is too short. To some extent, computer technology will begin to be used most effectively when schools allow for a schedule in which the day is divided up along more flexible lines, with a mix of time frames depending on the topic and medium of instruction (Riel, 1994).

There are other reasons for the slow pace of change Bulkeley (1988), Cuban (1986, 1997), Milken Exchange/ISTE (1999), and Brumfield (2006) add the following explanations for the uneven and limited penetration of technology into teaching practice:

- Teachers have inadequate opportunities for training and poor access to technology. Strategies for implementation are thus often flawed. In 1988, 32% of the computer-education coordinators in elementary schools admitted they were uncomfortable with computers, according to an Educational Testing Service survey (Bulkeley, 1988). By 1999, as already noted, only 20% of teachers felt prepared to integrate technology into the classroom (U.S. Department of Education, 1999). While most school districts now boast computer-education coordinators who are comfortable with computers, those coordinators' hands are typically tied by an appalling lack of resources, especially resources to provide support for ongoing training for the teachers.

- A surprisingly large number of colleges of education still do an inadequate job of preparing student teachers for a technology-based teaching paradigm.

- Integrating computers into instruction is much more difficult than expected and demands considerable preparation even for well-trained teachers.

- Classroom demands of various kinds—class size, heavy teaching schedule, other teacher responsibilities unrelated to teaching, and so forth—take away from a teacher’s commitment to computer-based teaching and learning. As one teacher put it: "I've been too busy teaching to integrate the computers" (Bulkeley, 1988).

A useful exercise would be to come up with your own reasons for the slow pace at which computer-based technology has been incorporated into instruction. These reasons might reflect your own experiences in the classroom, as either a student or teacher.

That the transition to computer-integrated curricula is slow should not surprise us; nor should it deter us from continuing to move forward. The April, 1992 report of the Council of Chief State School Officers, as relevant today as it was in 1992, called for access to technology "for all
Chapter 1: Technology Use in Teaching and Learning: What's the Return on Investment?

students" along with a proposal for "a series of sweeping measures to integrate technology on a broad scale in schools." Since effective leadership is so crucial to success, we must hope that commitments such as this, necessary but yet not sufficient for successful technology implementation in schools, will be taken up by administrations at all levels of government.

COMPUTER-INTEGRATED TEACHING AND LEARNING: THE TEN PILLARS OF SUCCESS

Here are some prerequisites for successful implementation of a technology program as a basis for further discussion (Table. 1.1).

<table>
<thead>
<tr>
<th>The Ten Pillars of Successful Technology Implementation</th>
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<tbody>
<tr>
<td>1. Leadership must provide active and committed support</td>
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<tr>
<td>2. Selling is better than telling—everyone needs to buy in to the change that technology brings</td>
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<tr>
<td>3. Invest in, and train, a core of teacher-technologists</td>
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<tr>
<td>4. Recognize that technological change is fast—keeping up-to-date is challenging and essential</td>
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<td>5. All teachers must receive on-going training</td>
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<td>6. All teachers must receive technical support—ideally on-site and on demand</td>
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<td>7. Use it or lose it—teachers must plan on integrating technologies in order to maintain currency and fluency in its application</td>
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<tr>
<td>8. Parents and students must be actively involved in the evolutionary process</td>
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<tr>
<td>9. There must be planned and systematic financial investment in technology-integrated teaching and learning</td>
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<tr>
<td>10. Recognize that technology is for all, and that it involves all in the process of lifelong learning</td>
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</table>

Table 1.1 The Ten Pillars of Success

In chapter 13 we will return to these Ten Pillars of Successful Technology Implementation in Schools and discuss them in greater detail. For now, read them, think about them, and discuss them with your classmates or colleagues. Every single one of the pillars needs to be in place for the successful implementation of technology for teaching and learning in our schools.
LOOKING BACK

This chapter has presented feedback from the collective experience of many educators and educational researchers with regard to the effective use of computer-based tools in schools. More work needs to be done. Current conclusions remain tentative though predominantly positive, suggesting that experimentation should continue with a view to helping teachers make wise decisions about ways and means of incorporating the computer into the curriculum. Experience also bears out the obvious caveat that any application of computer-based technology should be carefully evaluated as to its effectiveness. We'll return to this theme in chapters 4 through 9 when we examine the technologies and methodologies involved in computer-based learning and teaching.

Lewis Perelman, Director of Project Learning 2001 at the Hudson Institute, fires something of a broadside at people who continue to question the potential contribution of computer-based technology in schools. "Two decades of research," Perelman (1990) writes, "show that computer-based instruction produces at least 30% more learning in 40% less time at 30% less cost compared to traditional classroom teaching."

The leviathan that is education is stirring. When people look back on this period in the history of education, they will conclude that the invention of the computer was a critical catalyst for fundamental change in the way people learn, just as it is proving to be a catalyst for change in the way people live. Today we are on the threshold of this change, which means that these are difficult times. No one likes to let go of successful but outmoded methodologies. Teachers in training do not have much experience on which to base innovation since, for the most part, they were taught in traditional ways. But the pioneers are out there in the schools, and some of them are profiled in the Case Studies that accompany each chapter. Others are profiled in the many publications related to teaching in general, and to teaching with technology in particular. Appendix B reviews a selection of this recommended reading.

LOOKING FORWARD

Ideas are one thing, innovation another. Computer-integrated curricula yield significant benefits for students. This is recognized time and again in the hundreds of articles on this theme published every month in magazines and journals devoted to educational issues. Attend any of the dozens of conferences on educational computing that take place every year around the world and you will meet, unfortunately still very much in the minority, teachers who are taking the technology into their classrooms and, as we shall see in chapters 4 through 9, making it work for them and for their students.

But innovation requires hard work, planning and discipline. It does not just happen. Multitudes of teachers have attended seminars, workshops, conferences, even semester-long courses, where they have had the opportunity to learn how to use computer technology as a tool for teaching. A large proportion of these teachers have come away with a new-found enthusiasm for the methodologies involved. Too often, however, they have returned to their schools only to have that enthusiasm and excitement wane as reality brought home to them the extent to which they would have to change the way they have routinely run their classrooms.
The translation of ideas, and enthusiasm about those ideas, into practical implementation is often difficult. We should therefore not be surprised if change is slow in schools. Peters (1984) references the work of Theodore Levitt (1981) on the subject of ideas (creativity) and innovation in the business world. Levitt describes how difficult it is to effect change through innovation and makes a distinction between creativity and innovation. "Creativity," he says, "is thinking up new things. Innovation is doing new things..." Many people come up with good ideas that will improve the way things are done in schools; too few people are prepared to do what is necessary to implement their ideas.

Ideas take on life when they are realized through action. As Levitt points out: "Ideas are useless unless used." So we should resolve to be innovative as well as creative. Better yet, we should resolve to help others be innovative by our example, by our encouragement, and by our willingness to give our time and energy to promote the integration of technology across the curriculum at all levels of teaching and learning in our schools.
Chapter 2: Computer Hardware for K-12 Education

Chapter Two

Computer Hardware for K-12 Education

What we have not yet done is only
what we have not yet attempted to do.

*Alexis de Tocqueville (1805-1859)*

Good tools do not make a good teacher,
but a good teacher makes good use of tools.

*Eleanor L. Doan (1918-)*

LEARNING OUTCOMES

This chapter discusses the hardware components of the computer systems most commonly used in K-12 classrooms. There are, of course, many, many other types of computer systems, large and small. There are computers that control heart/lung machines, polling booths, automobiles, even traffic lights. But our focus is on the computers we use to help us teach and learn.

The most common computer you'll see in the K-12 classroom, traditional or otherwise, is the PC with an Intel microprocessor and a Microsoft Windows operating system (which is sometimes referred to as a Wintel computer, but for our purposes here on out will be referred to simply as a PC). Up until the early 1990s, Apple Computer Inc.'s Macintosh computer was also popular in schools, though this is less likely now to be the case.

Hardware is the term used to describe those parts of a system that you can see and touch—that is to say, machinery in the *solid* sense of the word. Another type of machinery—software—is made up of sets of logical instructions called *programs* that control what the hardware does.

Hardware, if you like, is the “body” of a computer system; software is its “soul.” Without software the hardware is useless junk—just like our bodies without the brain.

Just in case you think this is all too simple, bear in mind that some of the software in a computer is hardware and—yes, you guessed it—some of the software is embedded in the hardware.

When we use the computer we cannot *see* the software. We see only the *effects* of the software in the way the hardware behaves. Windows, Icons, Menus and Pointers (the components of the modern computer’s so-called WIMP interface) appear on the computer screen, beckoning us to interact with the computer system and inviting us to decide what we’d like to do.

Most everyone is now familiar with the mouse (hardware) which we grab a hold of and use to point (software) to what we’d like to do.

In this chapter, after briefly discussing the ever-growing presence of computers in K-12 schools, we will take a closer look at the computer’s hardware. We will conclude chapter 2 with a discussion of how to take care of computer system hardware. Then in chapter 3 we will examine the computer’s software "soul."
Chapter 2: Computer Hardware for K-12 Education

The topics that will be addressed in chapter 2 thus will include the following topics:

- Electronic Digital Computers Were Originally Invented to Meet Educational Needs
- The Components of a Basic Personal Computer System
- The Components of a Multimedia Educational Computing System
- Computer Maintenance
  - General do’s and don'ts
  - Do’s and don'ts regarding particular devices

ELECTRONIC COMPUTERS WERE INVENTED TO MEET EDUCATIONAL NEEDS

The story of computing spans many millennia; in fact it is as old as *homo sapiens*. If you are interested in reading this story, you will find a *PowerPoint* presentation on the subject which has been prepared to accompany this book at [http://www.pitt.edu/~poole/historyofcomputers.htm](http://www.pitt.edu/~poole/historyofcomputers.htm).

The gentleman who invented the electronic digital computer, essentially the same basic computer which we use today, was John Vincent Atanasoff (Fig. 2.1).

Fig. 2.1 Dr. John Vincent Atanasoff, inventor of the electronic digital computer
In 1937, Atanasoff, professor of Physics at Iowa State University, was already convinced that he could build a machine that would take the drudgery out of the mathematical, number-crunching research required of his PhD students. He teamed up with one of those students, Clifford Berry, to design and build the Atanasoff-Berry Computer, better known as the ABC (Fig. 2.2).

Atanasoff was not the first to express frustration at the time wasted doing relatively menial manual mathematical calculations. The PowerPoint presentation mentioned above identifies some of the "giants" in the history of computers on whose shoulders Atanasoff stood. One of these giants, Wilhelm Gottfried Von Leibnitz, who lived in the latter part of the 17th century and on into the 18th century, had this to say about computation and its automation: "It is unworthy," he said, "of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anything else if machines were used" (Shurkin, 1985).

This author recalls that in the 1960's in London, some of his high school students, usually of a mathematical bent, would accompany their mathematics teacher on field trips to local companies, where they would be allowed to program the monolithic computing machines which were, at the time, state-of-the-art. The students must have initially felt a little like they were entering the twilight zone, so awe-inspiring to them must those huge machines have been. But, human nature being what it is, the high schoolers quickly adjusted to the computers. The humdrum, limited scope of the machines would have become apparent to them as the novelty wore off. The thirst for more powerful machines, capable of handling richer problems at faster speeds, would have quickly become as insatiable then as it is today.
In the late 1970's, following the 1971 invention of the microprocessor by Intel Corporation, microcomputers first began to appear in schools. Some of those early machines—Commodore Pets, Radio Shack TRS-80s, early versions of the Apple II, and the IBM PC—are still around (mostly in museums) though they are unlikely to be still in use.

The Office of Technology Assessment (1988) noted that in 1981 only 10% of elementary schools, and 40% of high schools had even a single computer for students to use. By 1987 that proportion had increased to close to 100% for all grade levels. More specifically, by 1988 the ratio of computers to students in all schools was approximately one computer for every 40 students. By 2006, according to the National Center for Education Statistics, the average ratio of computers to students in the United States was a little better than 1:4, though there is now an increasing number of schools, in the United States and worldwide, where the ratio is 1:1.

Unfortunately, as pointed out in chapter 1, the proliferation of computers in schools is not necessarily accompanied by an equally rapid integration of their use as tools for teaching and learning. But at least it is true to say that students K-12 no longer need to make a field trip to use a computer!

In many school districts, the computers are electronically linked throughout the district so that students and teachers can communicate across age groups and between sites. They are also able to link to public access networks—such as the Internet, with its World Wide Web—that link the global social and academic community. The laptop computer, with a wireless connection to the Internet, along with the handheld computer, are becoming as ubiquitous as textbooks in a growing number of school districts and will certainly be far more common than desktop computers five to ten years from now.

This is no twilight zone. This is reality for those students fortunate enough to be already participating in an educational environment where computing technology has been woven into the fabric of the K-12 curriculum.

THE COMPONENTS OF A BASIC PERSONAL COMPUTER SYSTEM

This section examines the basic components of a computer—the minimum requirements of a useful system. Computer systems for use in the classroom can also include a range of other so-called peripheral devices, electronic tools needed to incorporate sound, video, still images and text into a multimedia learning environment.

Superficial features, dictated by hardware and software design, may make one computer system appear different from another. Today, however, these superficial differences are melting away as computer hardware and software manufacturers adopt common standards for the way we interact with the machines, otherwise known as the User Interface. One machine may be more powerful than another and have more features, but otherwise there will be few surprises in the way they function.

It is important for teachers to become skilled in the use of computers. Remember that you are learning about computers and how to use them well so that you can integrate them to your advantage when you teach and to your students’ advantage when you help them learn. The
appropriately programmed and integrated computer is perhaps the most effective tool for learning yet devised. The time and energy teachers invest in mastering this tool will yield a return that will benefit not only themselves, but also those they teach.

Readers will probably find it easiest to follow this section if they are sitting in front of a computer system as they read along. Figure 2.3 illustrates a typical setup for desktop computer systems found in schools today.

Fig. 2.3 The components of a basic computer system

The Monitor

The monitor is much the same as the television in our homes, used to display video. For this reason it is also called a VDT (Video Display Terminal). Occasionally you might still hear it described as a CRT (Cathode Ray Tube) because most every monitor, until the last ten to fifteen years, had a cathode ray tube as the mechanism for the display (as most every TV does, too).

But now, more and more computer screens use flat panel technologies for the display. This makes the computers more portable (as laptops) but also less cumbersome on the desktop. Flat panel displays don’t take up much room.

The display on a monitor is called soft copy in computerese. It is called soft copy because it is ephemeral, intangible, and short-lived. If you shut down the computer, accidentally or on purpose, the data on the screen are gone—unless you saved them on a disk or printed them out as hard copy on your printer.

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1 An important objective of this text is to introduce you to computerese. Like anything in life, there is an extensive vocabulary associated with computers which needs to be learned and which, once learned, helps to remove the mystery from these high tech machines.
Chapter 2: Computer Hardware for K-12 Education

The monitor keeps us informed about what is going on in the system unit of the computer, displaying the results of any processing the user has instructed the computer to do. This is necessary because it keeps us in touch with what is going on in the computer itself. What we see on the monitor reassures us that the system is behaving in a sensible way.

People who are sight-impaired also need such feedback, as it's called, and for them there are speech synthesizers that read the text on the monitor out loud, or there are braille monitors that consist of row upon row of raised pins that a sight-impaired person can read with his or her fingertips.

**The System Unit**

The system unit contains the computer chips\(^1\) on which are etched the tiny electronic components (switches and so forth) that enable the computer to do its job. Visually, we can think of the system unit like a miniaturized landscape. Objects—integrated circuits (ICs)—are dotted about, affixed to a logic board, and between the objects (ICs) are electronic highways or wires (called *buses*) that link the objects (ICs) together (Fig. 2.4).

As the technology advances, computers become *logically* and *functionally* more and more sophisticated even as they get to be smaller and cheaper. This is good news for everyone.

Let’s take a closer look at two of the key components of this system unit—RAM and ROM.

---

\(^1\) The chips described here are tiny devices (about the size of a little fingernail) that can hold millions, if not potentially billions, of electronic components etched onto no more than a sliver of silicon. They are often referred to as "silicon chips." In the mid-1960s, a new industry grew up around the manufacture of these chips in a valley, just south of San Francisco, which is now popularly called Silicon Valley. The industry of the valley used to be fruit farming, which is the origin of the name of one of the most successful computer corporations born in this valley—Apple Computer, Inc.
Random Access Memory (RAM) The system unit contains the internal memory chips, also called primary memory or random access memory (RAM for short). These memory chips are connected to the CPU and to each other by other buses or wires.

If you look at a RAM chip under a microscope, you can just about make out that it is made up of row upon tiny row of switches or binary digits—bits for short—to store data. The computer needs RAM to temporarily store the programs and data that will be used during processing. For example, when you want to do any word processing, you must first load the word processor program into RAM. Then, as you enter your text (the data) the computer stores in RAM the characters you type, too.

It is only when you save your work that your document gets transferred from RAM onto disk. Until then, your data is VERY vulnerable to being lost. If there’s a power cut, you’ll probably lose any work you’ve done since you last saved.

The size of RAM is measured in terms of how many bytes of data it can store. Which means it is time to learn more about those bits and bytes.

Bits and bytes A bit (the word “bit” is an acronym for “binary digit”) is the smallest unit in a computer and is one of billions of microscopic electronic switches which are used to store the instructions that tell the computer what to do. The bits are also used to store the data that the instructions tell the computer to process. Bits have only two possible values: 1 or 0.

A byte (made up of 8 bits) is a unit of memory on a computer chip that can store the equivalent of one character—such as a letter of the alphabet, like the letter ‘A’ or ’B’, or a punctuation mark, such as a period (.) or a comma (,). Fig. 2.5 illustrates this.

![Diagram of how data are stored in the computer as binary bits and bytes](image)

Later in this chapter you will learn more about how the computer represents data. For now, remember that the more storage room there is in RAM, the faster and more flexible the
Computer. It is not unusual today for the RAM of a computer to have many gigabytes of memory (a gigabyte is a little over one billion bytes or characters)!\(^1\)

Beware, though! RAM is a \textit{volatile} storage medium. A good definition of the word \textit{volatile} is the definition that applies when the same word is used to describe some gases, such as methane or hydrogen: they are "dangerously unstable." RAM depends on a steady supply of electric current in order to store data. If the power supply is turned off, the data are lost because the switches that contain the data are all turned off, too. This is why we need disk drives and other \textit{secondary} storage media. A disk (such as a USB or Flash drive today) is a non-volatile storage medium, capable of storing data \textit{after} the system has been disconnected from electrical power, or when the disk has been removed from the system.

Computer users sooner or later discover the difference between volatile and non-volatile memory. When you lose your work because you forgot to save it on the disk as you go along, you may lose your temper, too, and become very volatile indeed!

\textbf{Read Only Memory (ROM)} Besides RAM, the system unit also needs special internal memory chips that, like disk storage, are non-volatile—the content of these chips is retained even after the power is turned off. These are called ROM chips (ROM stands for read only memory). Their purpose is primarily to store programs and data that the computer needs in order to start itself up. This process is called "bootstrapping" because the computer is sort of picking itself up from within its own resources. When we turn on a computer and hear stirrings of electronic life, like the sound of disk drives spinning and the sight of images appearing on the screen, the instructions that trigger that life are stored permanently in ROM.

ROM is non-volatile because the instructions are "hardwired" onto the chips. The chips are actually built with the programs etched onto them (though these days the ROM chips are often electrically reprogrammable). As such the programs are physically, and therefore permanently, part of the hardware. For this reason, these programs are called \textit{firmware}—software that is permanently etched onto a chip's surface.\(^2\)

We do not need to know any more about the electronics involved in the system unit of a computer. Just be aware that if the system unit goes down, everything goes down!

\textbf{The Keyboard and Other Input Devices} With most computer systems, the keyboard is the most common means of getting data into the system for processing by the CPU. Other input devices include the mouse, trackball, joystick, graphics pad, a microphone for voice input, and so forth.

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\(^1\) By way of comparison, the average human brain has an estimated trillion neurons for storing data, with each neuron more or less equivalent to one bit in a computer. Eight bits make a byte. A billion bytes make a gigabyte. So we would need about 125 gigabytes of RAM to equal the storage capacity of the human brain. Computers, according to what is known as Moore's Law, double in performance capability every 18 months. So does this mean we can predict that there will be computers equivalent to the human brain by the year 2005? Not quite. The human brain has intelligence. A computer, on the other hand, is just a dumb machine, no matter how "intelligent" it may appear.

\(^2\) Today, more and more, these ROM chips are re-programmable
Handwriting recognition is another input technology that is receiving much attention, especially with the increasingly available Tablet computers, such as the one illustrated in Fig. 2.6.

You can also input commands to computers by touching highlighted areas on the screen. Such touch-screen devices are common for systems used exclusively for accessing information—such as those used in shopping malls, or tourist welcome centers. But it is likely that they will become common in classrooms. The same is true of voice input. Touch screen and voice input technologies have technical barriers that make them, as yet, still somewhat exceptional as technologies designed to simplify children's interaction with multimedia databases and other learning systems.

**Assistive technology** Many alternative keyboard-style input devices have been developed to help people with disabilities use computers. But even keyboards present a barrier to computing for some children. So other input devices have been developed which respond to the movement of a body part—the blink of an eye, the tracking of an eyeball, the puff of air through a straw, or the simple setting of a switch. Assistive technologies controlled in these ways are opening up the world of knowledge and communication for children once thought incapable of learning in more traditional ways. "No problems, only solutions" is becoming a mantra for the people who specialize in working with children with disabilities of all kinds.

Mainstreaming, the integration of children with disabilities into the same classrooms as other children, is more and more viable thanks to assistive technologies. We will return to this topic when we discuss educational computing environments in chapter 4.

**Disk Drive(s)**

RAM and ROM are examples of internal, or primary, memory. However, we must be able to store data outside the system unit for two reasons:

1. internal memory, you may recall, is volatile—when the power is turned off memory is erased; so a long term, external memory is essential;
Chapter 2: Computer Hardware for K-12 Education

2. the amount of memory in RAM and ROM is limited by the size of the machine and it is relatively expensive; so unlimited data storage is also essential.

The memory outside the system unit is called external or permanent storage. The four most common media for permanent storage are:

- punched cards—no longer a significant medium with modern computers, but used for centuries to control the music played by music boxes and from the earliest days of electromagnetic computing, including Hollerith’s Census Tabulator in the late 19th century;
- magnetic tape—used since the late 1950s;
- magnetic disk—hard disks or floppy disks, including zip disks and, now; optical disc—laserdiscs or CD-ROMs (Compact Disk-Read Only Memory), DVD (Digital Video Disc), CD-R and CD-RW
- solid state storage—such as USB Flash drives (also called “thumb” drives or “pen” drives)

Potentially, the supply of secondary storage is infinite; you just add storage media as needed.

Magnetic disk is still the most common medium for secondary storage of data. Magnetic tape and punched cards are rarely used with educational computing systems except, in the case of tape, as a massive backup storage medium for school network servers. But, to many people's surprise, punch cards are still used for voting—as the 2000 presidential election, with its dimples and chads, made us all too well aware!

Early PCs used magnetic cassette tape, but magnetic disks (the hard disk that comes with your computer, floppy disks and zip disks) are universally used today because of their speed and ease of data access. Optical discs such as CD-ROM, CD-R, CD-RW, DVD, DVD-R, DVD-RW\(^1\), also are essential components of desktop computer systems. We will return to optical storage later in the context of multimedia systems.

It is normal for a new system today to come with a built-in CD/DVD-burner. This is because so many applications require the extra storage capacity of optical media.

Remember: The disks are categorized as secondary (or external) storage. This is different from RAM, which we already discussed. RAM, also called primary (or internal) storage, is part of the system unit of the computer. RAM is only capable of storing data when the power is turned on. If you want to keep files after you turn off the computer, it is essential that you save them on secondary (or external) storage, such as magnetic disks or optical discs.

**How are data stored on magnetic disks?**

Data are stored using magnetized spots to represent the characters that make up the data that we want to save. Each spot (which is equivalent to a tiny magnet, by the way) can have a positive or negative charge—a positive charge typically represents a 1 and a negative charge represents a 0 (zero). One might find it easiest to think of these magnetized spots like switches. When the

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\(^1\) Optical discs such as CD-ROM and DVD are generically described as **WORM** discs (Write Once Read Many Times) which means they can be written to one time only, and subsequently read from as many times as you like, but they can’t be overwritten (the data erased and replaced). CD-RW (CD-ReWritable) drives and DVD-RW, on the other hand, are rewritable, so they can accomplish this latter task.
When a switch is turned on, it represents a 1; when the switch is turned off, it represents a 0. The 1s and 0s are the basic units of the binary (base 2) number system which is the language computers understand. Everything in a computer—the instructions that tell the computer what to do as well as the data that it manipulates—must be represented in 1s and 0s, as illustrated in Fig. 2.4 above.

As already mentioned above, special codes have been devised to enable a computer to store the data that we understand in our human language (letters of the alphabet, names, numbers, text in general) in the language of 1s and 0s. The most commonly used code today is ASCII\(^1\) code. The Table of ASCII codes is illustrated in Fig. 2.7.

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### Fig. 2.7 The Table of ASCII Codes (Courtesy www.asciitable.com)

For example, the uppercase letter A (towards the top of the third column in the table) is represented in ASCII as the decimal number 65 which in binary is the value 01000001. Each of the eight digits or switches is represented by a switch on the chip or disk—eight switches per character. Notice that ASCII Code includes a numerical value for every character on the computer keyboard plus a code for a whole bunch of other characters used for other purposes involved with operating a computer system.

The encoder is part of the computer's system unit, and it has the job of converting everything, whether typed at the keyboard or entered by other means, into the binary coded ASCII

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\(^1\) ASCII: American Standard Code for Information Interchange
equivalent. Each 1 or 0 is called a bit (bit, you may recall, is an acronym for binary digit), and all eight bits together are called a byte. One byte is equivalent to one character on a keyboard—such as a punctuation mark, a letter of the alphabet, a digit, and so forth.

So, for example, the ASCII code for the letter ‘A’—01000001—requires one byte (8 bits) of memory. In the Table below you can see the character ‘A’ highlighted. The decimal (Dec) value of the binary 01000001 is 65; the hexadecimal (Hex) equivalent is 41 (the binary 0100 = 4 in hexadecimal; and the binary 0001 = 1 in hexadecimal); and so on.

Using ASCII code you could easily write out your name using only 1s and 0s. You could also write a secret message to a friend—provided your friend also knows the code! Think of the 1s and 0s of machine language as if they were the characters of any other foreign language—a means of communication that needs to be translated from one language to the other before it can be understood and acted on. There’s no mystery here.

**Digitization** A computer can allow us to capture, represent, store, and manipulate literally anything, as long as we can come up with a way of converting it to the digits 1 and 0 (zero)—a process called digitization. Once the data are digitized they can be processed by the computer, stored on disk, or transmitted from one computer to another, as in now routinely done over the Internet. The process of digitization works equally well for images and sound as for the characters in a language. For example, a black and white picture can be divided up into tiny dots or segments (Fig. 2.8).

![Fig. 2.8 The process of digitization](image)

Think of the grid in figure 2.8a as if it were made up of row upon row of electronic switches, or magnetizable spots. Wherever part of the image of the face crosses a square in the grid, the switch is turned on in that square. This would be equivalent to the binary value "1" in the computer or on the disk (colored black when printed on the screen or on paper). Wherever a square is empty, the switch is turned off. This, of course, would be equivalent to the binary value "0" in the computer or on the disk (colored white on the screen or on paper).

The process of converting an image or audio or video clip to the 1s and 0s of the computer-based version is called digitizing. The dots that make up the image as displayed on the screen or on
paper are called pixels in graphics (pixel being short for picture element). Wherever there is a black dot in Fig. 2.8b above, the computer would store it as a "1" in memory. A white dot would be represented as a "0". The more dots there are to play with, the better the picture. Figure 2.8 is made up on a grid of only about 40 pixels by 40 pixels. That's just 1600 dots to play around with. This is considered very low resolution, as you can see for yourself. The fewer the pixels used to capture the image, the lower the resolution. The low resolution digitized version of the face in Fig. 2.8a is quite a distortion of the original (even though the original is not exactly a work of art!).

It is not unusual today to display images on high resolution computer monitors that have the capability of representing the images on a grid comprised of 1000 pixels by 1000 pixels. That's over 600 times the resolution of the images in figure 2.6b. The illustration of a smiley face could be digitally reproduced much more faithfully on such a high resolution monitor.

**Color graphics** How does the computer handle the problem of color or shades of gray? Well, the solution is to use extra bits to represent each pixel—up to 24 bits per pixel (hence the term 24 bit color), which enables the software designer or user to choose from a palette of $2^{24}$ different colors. That works out at over 16 million different colors! Fig. 2.9 illustrates the Microsoft Office interactive 24 bit color palette.

**Audio** Sound, as you probably know, travels in waves through the air and can be represented on paper as wavy lines. These, too, can be converted into 1s and 0s (digitized) and stored on a disk or in the computer's memory. Just as images such as our smiley face can be more faithfully rendered using more bits or pixels, so the more bits (1s and 0s) we use to capture a sound wave,
the more accurately we can represent it in the computer or on disk. Then we simply need a method for converting the digitized signals back into a form that can be reproduced as sound through an amplifier. This is more or less how compact discs (CDs) work.

**Printers**

A printer rarely used with computers in schools today is the dot matrix printer. *Dot matrix* means that a character that is printed on the paper is formed by a set of pins (a matrix of pins) organized into the shape of the character that is then smacked against the printer's ribbon and thence imprinted onto the paper. Dot matrix printers used to be very popular in schools because they were cheap. Unfortunately they have several disadvantages. They are slow, noisy, and produce output that is not of the highest quality.

An acceptable alternative to the dot matrix printer is the inkjet printer which, being a non-impact printer, is quiet and less likely to break down. It also produces good quality output. It is, however, relatively slow and not ideal for heavy use, such as in a school's computer laboratory. But the inkjet printer is a fine, inexpensive option for the home.

Laser printers, on the other hand, are relatively fast and quiet, and produce output that is close to professional print shop quality. The print quality of laser printers is invariably good as long as everything is in good working order.

Printers, like all machines, have to be maintained to produce optimal results.

**The Mouse**

The mouse, in terms of hardware, is the palm-size critter that sits on your desktop next to the computer. Unless it's a wireless mouse, it has a tail, of course, that snakes its way to the socket in the system unit, and is designed to run around on the desk (under your control, of course!). Older mice have a couple of moving parts: a track ball underneath which controls the movement of the cursor on the screen and one or more buttons on top which you click to carry out the tasks that are pointed at by the cursor on the screen. Newer mice still have the buttons, but they use a beam of light to track movement instead of a ball. If you are not already accustomed to using the mouse it can take a little getting used to. But it's like learning to walk; once you get the hang of it, it's as easy as pie!

**THE COMPONENTS OF A MULTIMEDIA EDUCATIONAL COMPUTING SYSTEM**

Multimedia computing systems are now the norm. Chapter 10 discusses the whole concept of multimedia, while chapter 11 discusses creating multimedia experiences for and with your students, including the software enabling teachers and students to author their own interactive learning applications. Here we will briefly consider what hardware components should be included in a classroom where multimedia is an important learning environment.

The hardware required consists of the basic computer system already described above, plus some or all of the following components:
Chapter 2: Computer Hardware for K-12 Education

- **Mass data storage systems** (other than your hard drive) to provide unlimited removable storage for audio-visual files: a USB Flash Drive or Thumb drive; a DVD rewritable disc drive otherwise known more popularly as a “burner”.

- **Display devices** such as: a high lumens projector to which various devices such as a visual presenter, VCR, or optical disc player, can be connected for display onto a large screen in front of the class; a large, high resolution color monitor.

- High quality **speakers** to take care of sound.

- a **scanner** for digitizing still images such as photos and other graphics that are only available in hard copy form.

- a **digital camera** for capturing still images, and a **digital video camera** for video clips of activities in the classroom or in the field for processing in the computer;

- a **visual presenter**, aka document camera, rounds out a multimedia system by adding the capability of displaying three dimensional objects and live demonstrations on a large screen.

Let us briefly examine these multimedia-enabling computer system peripherals one by one.

**Mass data storage systems**

Optical devices, such as CD-ROM/DVD, which use laser as the data storage medium, have become more or less standard for the sharing of video or audio data such as film or music. This is because the optical medium is more than adequate for processing audio-visual information. Optical discs are cheap and capable of holding large volumes of data in a small space, and video is especially demanding in this regard.

As mentioned earlier in this chapter, there are two kinds of optical disc drive that use laser technology to store data: CD-ROM/DVD drives which use 4¾" discs, and interactive videodisc (also called laserdisc) players that use 12" discs or platters. Laser technology is now also used to “burn” data onto blank CDs, such as CD-RW discs (which can both Read and Write information) and CD-Rs (which can be written to once and then only read from thereafter).

Laser-based storage technology can store data much more compactly than magnetic storage technology. This is critical when it comes to video images such as movie clips because so much data are needed to represent each image—remember those pixels we talked about earlier in this chapter?

Ideally, a moving video sequence needs to be "refreshed" on the screen at a rate of 30 frames a second and each frame has to be captured on the disc. Special compression techniques are used to save storage space, but nonetheless no more than about an hour or two's worth of video can be stored on optical discs such as DVDs or interactive video discs.

Laser technology is often referred to as optical technology because beams or pulses of light (optics) are used to read and write the data on the discs. Data are usually stored on the surface of the optical disc using microscopic pits or indentations that are burned into the platter by a laser beam. The data on CD-ROM discs are in this way represented as 1s and 0s on the tracks that
spiral\textsuperscript{1} around the disk's surface. A pit is used to store a "1" on the disc's surface; where there is no pit (called a "land"), the system interprets that as a "0". It is as simple as that.

Where there is fiber optic cable connecting the computers on a network, the data can be transmitted at extremely high speed as pulses of light. We'll discuss this technology more in depth in chapter 7 when we describe the different media used for telecommunications. As yet, however, when optical data is read from the disc, the data must be decoded into electronic form so that they can be processed in the computer, displayed on the monitor or, in the case of music and sound in general, amplified over the speakers. This, but above all the slower rotation speed of optical disks, makes processing data from optical media slower than that from magnetic media such as hard disk. The slowest and least capacious medium for data access and storage is floppy disk which is why this technology is slowly but surely being phased out.

Researchers are currently refining the technology which allows computers to process data in the form of pulses of light. Such laser computers will operate considerably faster than the current electro-magnetic machines, if only because there will be no need for the process of encoding and decoding the data from one physical medium to the other.

\textit{Display devices}

Education has always emphasized video and graphic images as a stimulation to inquiry learning. Along with the availability of whole libraries of on-line textual material, there is an ever-increasing abundance of high quality still and motion picture material that multimedia systems typically tap into. Today, more than ever, teachers can take advantage of multimedia materials appropriate to all age groups and in all subject areas.

The display technology is a critical component of a visually-oriented information delivery system. This is especially true when the material is to be presented to larger groups such as a class of children. So a large screen, high resolution display device such as a large screen TV monitor or a projector which can project onto a drop-down screen in front of the class is almost a must. Fig. 2.10 illustrates a ceiling-mounted projector that is wired to a computer and other audio-visual devices in the classroom.

\begin{figure}[h]
\centering
\includegraphics[width=0.3\textwidth]{fig210.png}
\caption{Ceiling-mounted projector}
\end{figure}

\textsuperscript{1} The track into which the pits are burned is actually a continuous path that starts near the center of the disc and spirals its way towards the outer edge. The tracks on a magnetic disk, by contrast, are concentric—each track is independent from the others.
This projector can also be mounted on a desktop or table top to project onto a large screen the data from a video cassette recorder (VCR) or visual presenter/document camera or from the computer itself. Alternatively, and less expensively, a good quality LCD panel laid on top of an old-fashioned overhead projector can display the data from the computer onto a large screen or even onto a light-colored wall surface. LCD panels, however, have now more or less been superceded by projectors such as those illustrated on the previous page.

**Speakers**

A good quality sound amplification and speaker system enriches the experience of audio-visual material. It really does not pay to nickel and dime on audio-visual (A/V) systems because students today are accustomed to quality systems at home. Like it or not, students can easily be turned off a valuable learning experience by inappropriate, antiquated, or inferior quality A/Vs.

**Scanners**

A scanner is a device that converts images into digital format by reducing them to a matrix of dots (pixels) as illustrated earlier in this chapter. (See Fig. 2.7 above). Each dot has a binary value made up of 1s and 0s that captures the exact characteristics of the dot. If the image is black and white, just one bit (1 = black; 0 = white) is sufficient to describe the dot. If, on the other hand, the image is rich in color, more bits (up to 24 bits to be precise) are required depending on the range of colors the system is designed to handle. 24-bit color is capable of representing over 16 million different colors. This may seem like a large number of different colors, but the fact is that there is an infinite number of different colors in the universe of colors, so 16 million is actually but a small selection of all possible colors. Fax machines, which create a digitized version of an image and then transmit it, bit by bit, over telephone lines to some other location are scanners connected by modem to the local and wide area networks that make up the telephone system. You'll learn more about modems and local and wide area networks in chapter 7.

**Digital cameras and digital video cameras**

The digital camera and digital video camera, which are now well on the way to replacing traditional analog\(^1\) cameras, are ideal multimedia tools for gathering ad hoc, school-related visual materials to include in projects across all subject areas and age groups. Nowadays, digital cameras are capable of capturing both still image and video, as is the case, too, for video cameras or camcorders.

**Visual Presenter (also called a Visualizer or Document Camera)**

A visual presenter, also called a visualizer or document camera, is the ideal tool for the display of objects and demonstrations that are too small for all the class to see at once. A simple visual

\(^1\) Analog is the opposite of digital when it comes to data processing. An analog camera captures on film all the light that comes in through the lens, just like the human eye. A digital camera captures a matrix made up of individual samplings of the light coming in through the lens and stores it directly as 1s and 0s, in digital form, on a disk, a tape, or a computer chip inside the camera. So the analog image of traditional cameras is a more accurate representation of reality, but a digital image, though inferior in many ways, is much easier to process, store, manipulate, and transmit.
presenter is a video camera mounted on a stand and connected to a projector which projects onto a screen whatever the camera is viewing. Teachers and students can place under the camera whatever they want the class to see, whether it be a bug or a butterfly, magnetic filings and a magnet, a gemstone or a geometric model—anything. Even the simplest of visual presenters include the capability of zooming in on tiny objects.

You get what you pay for, of course, and more expensive visual presenters provide sharper images, with greater magnification capability, and allow the user to vary the light source from above or below the objects being displayed so that the presenter can also be used for slide transparencies and even for the display of 35mm slides (Fig. 2.11).

Fig. 2.11 Sony’s DC-13 visual presenter

MAINTAINING YOUR COMPUTER SYSTEM

This section will deal with some of the dos and don'ts of taking care of a personal computer system. Ideally the computers in the schools will get a great deal of use from children. You should, therefore, be aware of problems that can arise with different parts of a computer system, and know how to avoid them, so that you can instill in your students appropriate behavior around the machines. The following compendium of correct practice will go from the general to the particular, focusing first on the classroom or laboratory environment in which computers are found, and then on the specific components of a system.

General Do's and Don't's

- Don't smoke around the equipment, and keep it covered when not in use. Dust and smoke can damage the tiny components of various devices, especially disk drives. Covering the computer would be especially important in a classroom. There is often a chalkboard, and there are always children! Even "dustless" chalk creates fine grain dust, and children bring in and kick up their fair share of airborne particulates.

- Use a surge protecting power strip to plug in the various components of the system. Unusual "spikes" in the electrical power supply can "fry" the circuits on the computer chips. Surge
protection devices can be purchased at little expense and will save you hundreds, if not thousands, of dollars worth of damage.

- Keep food and drink away from the equipment. This is a difficult one for children and adults alike. Crumbs and sticky liquids can gum up the works and short out electrical components.

- When you dust down the various machines use a damp cloth so that the dirt is carried away from the machine. If the keyboard is separate from the system unit, hold it upside down while you clean it. A can of pressurized air, easily available at computer or office supply stores, can also be used to blow out loose particles of dust and dirt.

**Taking Care of Disks**

It might not seem important to cover this topic, and you might be tempted to skim through it, especially if you have already held a disk in your hand and it looks robust enough. The fact is, however, that more grief is caused through careless handling and use of disks than any other component of a computer system. Even if you think you know all there is to know about disks, read on to see if there are one or two tips that will help ensure you trouble free use of computers in the future. This section will also be useful when you are teaching your students to use computers.

**Magnetic disks are damaged more easily than you think**

Here are some of the things that can happen to cause damage to the disk, and therefore loss (accidentally, of course!) of any data that might be stored on it:

- **The disk can be bent, especially the metal flange that slides back and forth.** One bend anywhere can be enough to make the disk unusable. Disk tossed loose into school bags are especially vulnerable to damage. They should be kept in disk carriers (plastic boxes designed to store single or multiple floppy disks) or at the very least in something like a zip lock bag which will prevent the metal flange from getting caught on other objects in a school bag.

- **Sticky food or drink can be spilled on the disk's surface.** How easy it is to innocently put a disk down on a table only to discover that someone (never you!) has not cleaned up coffee or fruit juice that was spilled before your arrival. And, of course, the disk containing your most treasured data will invariably be the one that's lying around when someone knocks over a can of Coke!

- **The disk may get overheated** by being left in a car on a sunny day. Extreme cold can also cause a disk to become unreadable, though this is less likely—unless, perhaps, you live in Alaska!

- **Any magnetic field (such as the ones on the refrigerator door) brought into close proximity with the disk will erase the contents** since the data are stored in electro-magnetic form.

The simple protection against such hazards?

- Make a backup copy of ALL your disks, no matter how unimportant you might think they are. This takes a little extra time at the end of sessions during which you have been working at the computer, but the payoff in peace of mind is well worth the effort.
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- Identify your diskettes by writing your name and the contents on a sticker attached to the disk. Usually you will write on the sticker label before you attach the label. Write legibly using pen rather than pencil so it's more difficult to erase.

- Disks should be carried around in a container. Even a zip lock bag is better than nothing. Disks are easily damaged when tossed unprotected into a student book bag.

The more you use computers, the more disks you will have lying around. It is surprising how easy it is to lose track of the data files that you have collected after you have been using your computer for even just a few months. You should set up a system for storing them carefully at home or in the office. This is especially true of optical media, such as DVDs or CDs, which can easily become unreadable because of scratches on the surface. Larger containers can hold as many as 50 disks at a time. Attach labels to the tabs separating different sections and thus catalog the disks so that it is easy to retrieve the one you need at any particular time. Don’t stick labels on the surface of a DVD or CD, however, since the resulting imbalance can cause damage to the drive. Fig. 2.12 illustrates a couple of solutions to the storage problem.

Fig. 2.12 Disk storage solutions

- Don't leave disks lying around, even in the office. The risk of loss, damage, or vandalism is obvious. Consider how important the data stored on those disks are to you, and take appropriate security measures to safeguard their integrity.

The key always is to handle disks with care and devise a system which enables you to find any files you want wherever they are and whenever you need them, which is the subject of the next section.

**Organizing your data on disk**

This is a task usually given far too little attention compared to the attention that it deserves. If you are new to computing you have yet to discover how easily you can lose track of the work you have stored on disks. If you are not new to computing you are no doubt nodding your head in agreement! There are two simple strategies to solve this problem:
1. **Always give your files meaningful names**

   If it is a file about grades, call it Grades. If it is a document about field trips, call it Field Trips or FldTrips. Notice that even the abbreviation is at least a mnemonic—it sounds like the name and so reminds you of it.

   Don’t!!! use a name (Stuff, Junk, XYZ, Whatever ...) that will be meaningless to you once you have forgotten why you named the file or document in the first place.

2. **Learn how to create and manage subdirectories or folders on your system**

   Subdirectories or folders are like the drawers in a filing cabinet: they enable you to store your files according to categories of your choosing.

   After a while you may have a collection of letters saved on your disk. Put them all in a subdirectory called *Letters*. You'll have different types of letters, most to parents, but some to friends and others. Create one subdirectory *inside* the Letters subdirectory called *Parents* and another called *Other* and separate the letters accordingly. Fig. 2.12 illustrates this practice.

   ![Fig. 2.13 Subdirectories or Folders](image)

   Notice, in Fig. 2.13, how the folder named *Bernie Poole* contains a subset of folders, including one called *School*, which itself contains a further subset of folders related to school affairs.

   You should be careful to organize all your documents in this way. You’ll save yourself no end of time in the long run. This way, when you look at the list of subdirectories and files in your top level (root) directory, you will easily be able to “drill down”, as they say, and find whatever file
This may sound trivial, but it ceases to be so when you have a gazillion files and you can't find the one you desperately need.

Printers for multimedia systems

The appearance of your printed output (called "hard copy" in computer-ese) ultimately depends on the quality of your printer. It also depends on how well your printer has been cared for. Of course, if you have a cheap printer, you can hardly expect to get anything other than low quality results. But often a printer can be made to look cheap because it is not cared for and/or because it is not used correctly.

If by any chance you have an impact printer, such as a dot matrix printer or a daisy wheel printer, you may have to worry about noise, especially if you expect the printer to be used in the classroom while other teaching activities are taking place. To cut down the noise you can buy, or rig up, a cover to act as a muffler for the sound.

Non-impact printers, such as laser printers and ink jet printers, have fewer moving parts than impact printers, and therefore tend to be more reliable. They also make a minimal amount of noise, and print much faster than the kind of impact printers you're likely to see connected to computers. Today such printers are the norm because the cost has come way down compared to a few years ago. Indeed, it is not unusual for a printer to include other functions, such as copier or scanner and (when connected to the phone system) fax (Figure 2.14).

Fig. 2.14 Dell’s A960 All-in-One Printer, includes scanner, copier, and fax

1 A daisy wheel printer uses a fixed head for the type font, unlike the dot matrix printer which uses a matrix of pins to form the character on the paper. The name "daisy wheel" comes from the fact that the characters are set on the end of spokes radiating from the center of the print head. The wheel rotates till the required character is in position, then the hammer hits the character at the end of the spoke against the ribbon and thence onto the paper.
LOOKING BACK

The material in this chapter has been included for the benefit of the newcomer to computer technology. As such it also may be useful for teachers who are already familiar with the computer but who have not yet actually taught computer use to children. For this latter group there may well be material in this chapter that will be of value in the classroom, such as ideas for how to explain certain aspects of the technology, useful tips for system maintenance, and so on.

Even if technology may not interest you per se, you should still try to understand at least the basics of how machines in general, and computers in particular, work. The more you understand the mechanics of a tool, and practice is key to this understanding, the more effectively you will be able to use it.

LOOKING FORWARD

Chapter 3 will examine the different types of software you need to control, and take advantage of, a computer’s capabilities. The software is the key to a computer system’s usefulness. We buy computers only so that we can use the software for a wide variety of data processing tasks.

There are two types of software: system software and applications software. The system software makes it possible for you to use the applications software. Good system software enables you to use the computer without your being aware of the complexities of the machine. In other words, good system software allows you to concentrate on the application, what you want to do, the task you want to complete, using the computer as a tool to that end.
Chapter Three

Software Systems for Personal Computers

Those who educate children well are more to be honored than those who produce them; for these only gave them life, those the art of living well.

*Aristotle (384-322BCE)*

There are no shortcuts in the quest for perfection.

*Ben Hogan (1912-1997)*

The notion of time is an intellectual construction.

*Jean Piaget (1896-1980)*

**LEARNING OUTCOMES**

In the previous chapter you learned about the hardware of educational computing systems. You also learned about one particular part of the hardware called ROM—Read Only Memory. You may recall that ROM is comprised of computer chips on which are etched programs used by the Central Processing Unit (CPU) at start up to bring the system to life, so to speak—a process called *bootstrapping*. The CPU reaches down into the ROM chips to get the instructions that enable it to receive further instructions from other parts of the system. Turning on the power switch acts as a wake up call for the computer to go through this bootstrap routine, flexing its muscles and shaking itself awake to greet a new day. Without these basic routines or programs the computer would be useless.

Bootstrapping is the term used to describe the process whereby the computer, when the power is turned on, loads the operating system—the underlying software that allows the system to do its work—like the engine in a car, though it’s a bit more complicated than that. In this chapter we will learn more about the functions of operating systems. We will also learn about two other types of software that depend on the operating system and that are essential to productive use of the computer. These are the user-interface software and applications software.
Chapter 3: Software Systems for Personal Computers

It is beyond the scope of this book to present the ins and outs of any specific operating system, user interface, or application. However, tutorials for the various versions of Microsoft Office have been written to accompany this text and may be found online at the following web addresses:

- Essential Microsoft Office 2000
  http://www.pitt.edu/~edindex/Officeindex.html
- Essential Microsoft Office XP
  http://www.pitt.edu/~edindex/OfficeindexXP.html
- Essential Microsoft Office 2003
  http://www.pitt.edu/~edindex/Office2003frame.html
- Essential Microsoft Office 2007: Tutorials for Teachers

Chapter 3 will introduce you to the key features of the three basic types of software: the operating system, the user interface, and applications. The focus, however, will be on the operating system and the user interface. This is because, in chapters 5 through 10, we will examine a range of applications software that has proved itself effective in the classroom when carefully integrated into the K-12 curriculum.

Specifically, this chapter addresses the following topics:

- The Layers of Software
  - Firmware: software that is part of the computer's hardware
- The operating system
  - A definition of a traditional operating system
  - The definition of a modern operating system
  - The operating systems most commonly found in schools
- Utilities
  - Common operating system functions
  - Useful user-controlled operating system functions
- The Graphical User Interface (GUI)
  - The problem of non-standard user interfaces
  - Standardization through integrated software or suites of programs
  - Standardization through graphical user interfaces (GUIs)
  - Some background history of the GUI
  - GUIs and educational psychology
- Applications software

THE LAYERS OF SOFTWARE

At the heart of any computer system is the hardware, discussed in the previous chapter. Layered onto the hardware are the different types of software that allow us, the users, to carry out useful tasks. Figure 3.1 on the next page illustrates this idea.
Chapter 3: Software Systems for Personal Computers

An operating system is often represented as the inner of the layers of software that make the power of computing machinery available to the user. As you can see, the operating system, comprised of a set of programs, comes between the hardware and the applications software. The operating system makes it possible for us to work (use applications) on the computer without having to worry more than absolutely necessary about the computing machinery involved in the background.

The user interface (most commonly Microsoft’s Windows graphical user interface or GUI) is the set of programs that controls the way in which the computer system makes itself available to the user. A well-designed user interface will go a long way to accommodating a diverse world of users.

Fig. 3.1 The Layers of Software

The user interface (GUI) consists, on the one hand, of the software that controls how you interact with the computer system, whether by typing at the keyboard, or by pointing and clicking with the mouse, or by issuing voice commands, or by touching the screen, or by pressing a switch. On the other hand, the user interface consists of the software that controls how the computer interacts with us, whether by displaying text on the monitor or on a printer, or responding in other ways such as flashing or beeping or talking back to you, and so on.
**Firmware: software that is part of the computer's hardware**

The arrows connecting the different layers of software in figure 3.1 indicate that all the programs that you are using at any one point in time—the operating system and the applications, along with the user interface—must be loaded into the computer hardware, in either RAM or ROM, so that you can do your work. ROM, you will recall from chapter 2, contains at the very least the programs that the system needs to set itself up (called bootstrapping) and to make itself available to carry out all the other tasks required by you, the user. This basic set of programs is called the Basic Input/Output System—BIOS for short.

The BIOS is part of the operating system software that is hardwired onto the ROM chips. For this reason it is called firmware—software that is part of the chips' hardware. The advantage of firmware is Speed with a capital S! The system can access data much more quickly from primary memory (RAM and ROM) than from secondary memory (the disk drives). Indeed, the firmware contains the instructions necessary to access secondary memory in the first place.

Firmware is thus software that has been hardwired onto the chips which are part of the computer's hardware. Until the 1980s and 1990s, firmware was a relatively precious commodity because the density with which the electronic components (switches and circuits and so forth) could be packed on to the surface of the chips was not great. However, there have been breathtaking advances in chip technology since the integrated circuit was invented in 1958. Speed, as was noted in chapter 2, is a function of space and there is a rule of thumb called Moore's Law\(^1\) (Moore, 1965) that predicts that computers will double in processing power every 12 to 24 months. This doubling occurs because the computer engineers have relentlessly microminiaturized the switches on the chips and in other ways optimized their performance.

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\(^1\) Gordon Moore (Fig. 3.2), one the founders of Intel Corporation, hypothesized—correctly thus far—that the processing speed of microprocessors would double on average every 18 months. At times this doubling has occurred at 12 month intervals, at others 24, but the 18 month average seems to be holding up. The speed of microprocessors, now at the 2 gigahertz rate plus, is such that doubling is a significantly more dramatic phenomenon than ever.
In general, the more circuits that can be packed onto the surface of a computer chip the more powerful the machine is and at a cheaper price. It will soon be possible to store 100s of millions of electronic components (bits or switches, as they are called) onto a single chip no bigger than your little finger nail. You need 8 bits to store one character, and on a typical printed page of text you have maybe 3,000 characters. So if all you wanted to do was store text, you could easily store on a single chip the equivalent of over one hundred 500 page books! Because of higher capacity, many hardware manufacturers now include diagnostic and other utility programming as firmware on computer chips.

For the time being most software is still loaded into RAM from secondary storage. The computers you will be using in schools have either magnetic disks or optical discs for this purpose, and it is the operating system that takes care of the humdrum tasks involved in running the software on the system. This is the subject of the next section.

**THE OPERATING SYSTEM**

The primary objective of this section is to encourage you to learn about the operating system of any computer you use because to do so elevates you to the level of a power user of that system. A very high percentage of computer users, understandably to some extent, learn only what they think they need to know about a computer to run a particular application such as a word processor. They never discover the many useful, built-in functions of modern computer operating systems such as sorting, merging, backup, use of subdirectories or folders, copying files and disks, multitasking, and on and on. As a result, even the little use they make of the computer is inefficient, often disorganized, and sometimes disastrous, as when data are lost because of failure to backup files.

Familiarity with your computer's operating system gives you a higher level of control over the computer, which translates into power and peace of mind. A secondary objective of this section is thus to help you appreciate the value of the operating system.

Using a computer would be a nightmare if you had to manage all the computer's resources for yourself—which is what the early computer pioneers had to do before they cottoned on to software-controlled operating systems. Not so long ago (1970s), the computer operator was a person. People studied for an Associate Degree in computer operations. That was before systems programmers wrote the software that now allows a computer to more or less take care of itself. For the most part, people like me and you are now thankfully relieved of this responsibility.

So… What is an operating system? It is beyond the scope of this book to present the features of all but the most common computer operating systems, and we will focus on operating systems for personal computers. Operating systems, however, now all behave in much the same way. Any differences are the result of idiosyncrasies built into them by their creators.

**A definition of a traditional operating system**

We can say that an operating system consists of a set of programs that give added value to the computer by making available to the user the full resources of the computer hardware for which the operating system has been designed.
An operating system not only allows a computer to manage its operations and resources, but it also makes them available to you, the user, so that you can carry out the various applications that you had in mind when you bought your computer. An operating system thus makes it possible for you to get the utmost out of the computer's various control, input, output, and communications components. Davis (1978) put it this way: "A well-designed operating system is not concerned with just hardware or just software or just data management, but with optimizing the way in which all of these resources work together."

The quotation from Aristotle at the opening of this chapter was not chosen simply to make you feel good about your choice of teaching as a profession. It also has some analogous relevance to operating systems. Without stretching the analogy too far, one might say that an operating system is to a computer what an education system is to a child.

An understanding of this idea might deepen your appreciation of the role of an operating system.

The behavior of a human being is to some extent determined by innate capabilities—nature if you will, about which you learn a great deal in your education and psychology classes at college. These innate capabilities are akin to the characteristics of a computer that are built into the machinery, hardwired onto the chips in the CPU and ROM. One does not have too much choice about them. We are who we are, just as a computer is distinctively whatever model of computer it is designed to be.

As children grow, however, they are exposed to life as it happens to them and around them—nurture, if you will. One way or another, they become educated. This process of education (nurture in the broadest sense) further individuates a person, ideally for the better—hence the crucial role of good parenting and of good teachers. Aristotle is implying, of course, that the best parents are also good teachers.

Continuing the parallel between a person's education and a computer's operating system, we might say that the operating system gives the computer an extra layer of individuation or character, if you will forgive the anthropomorphism. An operating system thus increases the potential of the computer to serve our needs, just as education aims to increase the potential of the human being.

**The definition of a modern operating system**

Today we can refine our definition of an operating system by adding one ingredient that is having a dramatic impact on computer use. This ingredient is accessibility. With accessibility in mind, we can rewrite the definition of an operating system as follows:

- A modern operating system consists of a set of programs that gives added value to the computer by making available to the general user in an easily accessible way the full resources of the computer hardware for which the operating system has been designed.

The ingredient of general accessibility was a side issue for the first thirty years or so of operating system design, largely because it was too expensive to implement, but also because computer users were almost invariably technical experts. At first, the hardware technology just was not powerful enough to handle both the processing involved in carrying out computational tasks and at the same time present a comfortable, user friendly face to the world. Also, the early users of
computers were invariably techie types who relished the challenge of figuring out how to make a computer do what they wanted. Some of these techie types even resisted user-friendly interfaces. In the mid 1980s, this author overheard one computer "nerd" declare to another, "I hate the Mac; it's too easy to use!"

Fortunately, in anticipation of the machinery of computing becoming capable of handling interactive displays using colorful, high quality graphics, a few insightful individuals in the 1960s and 1970s, Doug Englebart and Alan Kay in particular, designed and wrote programs that transformed the computer into a machine that invites use by ordinary people like you and me! We'll take a closer look at these inventors' work later in the chapter.

A good operating system today does its job in such a way that you are barely aware of the complex activity that has to go on in the background. When you or your students use the computer to do some word processing or practice math skills or engage in any one of the myriad applications designed for computers, you will not have to worry about how the computer manages the cursor on the monitor screen, or how the system finds the data on the disk in the disk drives, or how files are copied, or how the system switches from one process to another. The full capabilities of the machinery are easily—and transparently—available to you.

If you are old enough to have used personal computers in the early 1980s, you no doubt appreciate what a difference the graphical user interface (or GUI) has made.

**Utilities**

A utility is a program extension of an operating system. More and more utilities are part and parcel of the operating system, so they are already installed when you buy the computer. Think of a utility as a tool on a workbench\(^1\). It helps you make more efficient use of your computer.

For example, most of today's operating systems have built-in calculators. All the computers have clocks which include the date. A notepad is useful for To-do lists, memos, reminders, and other jottings. The Mac has a scrapbook, very useful for cutting and pasting, and for gaining ready access to your favorite graphic images. Programs for painting and drawing are now part of the operating system, as are tools for working with graphic images such as photos and creating and editing movies. These latter programs are relatively simple when it comes to what they can do, but they are easy to use. Expert graphic and movie editors will want to purchase more sophisticated software than what is built into operating systems.

Accessibility tools are part of the built-in set of Windows XP programs, such as tools for the sight impaired which magnify text or narrate text out loud. There is also an onscreen keyboard for touch screen typing using the mouse to point and click on the letters—useful for folks who have difficulty using their hands to hit the keys on a keyboard.

A utility also helps you accomplish certain tasks that extend the capability of the computer. These utilities are called Accessories in the Windows operating system. Disks which have become fragmented, for example, with pieces of files spread out all over the disk, can be reorganized and optimized (defragmented) to make data storage and access more efficient. We will return to this

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\(^1\) The operating system for an early PC called the *Commodore Amiga* used the name *workbench* for its Graphical User Interface, and the available utilities were called tools.
subject shortly when we discuss the functions common to operating systems for popular educational computing systems.

Other utilities, especially utilities for protection against computer viruses, are provided by independent software companies, such as McAfee, Inc. or Symantec Corporation's Norton Utilities. These packages of security utilities not only provide tools to protect your computer from viruses, but also restore lost files, manage memory, and accelerate access to the data stored on your disks. Crashed or accidentally formatted hard disks can be diagnosed and recovered. Files that have been trashed can be recovered, too.

The number of utilities available today is too large to list here. As you become more and more familiar with your computer, and as you exchange ideas about computing with your classmates, colleagues and students, you will discover those utilities that are most useful to you.

**Common operating system functions**

Here is a list of functions typically taken care of by the operating system of a modern personal computer; the operating system must:

- manage the transfer of data between primary storage (RAM) and secondary storage devices;
- manage the secondary storage medium itself along with the data stored on it;
- manage the transfer of data between peripheral devices and RAM;
- manage computer interaction with communications devices and provide support for communications networks;
- manage the allocation of storage space in RAM to several applications (multitasking).

Let us look at each of these in a little more detail.

**Managing the transfer of data between primary storage (RAM) and secondary storage devices**

Typical secondary storage devices on PCs are hard and floppy magnetic disk drives, including zip drives and USB Flash drives, and optical disc drives such as CD-ROM and DVD drives. These devices were described in some detail in the previous chapter on hardware. Several tasks are involved in the transfer of data to and from the disks. If data are being transferred ("input") from secondary storage to RAM, the operating system must locate the correct pieces of data, belonging to the correct file, on the correct disk, in the correct drive. This may mean following a trail of pointers if the file is split up into sections on different parts of the disk.

As the data are transferred into RAM they must be stored in memory locations on the computer chips that have not already been taken up by other instructions and data. And when the file is stored back on the disk the operating system will have to find free space on the disk if the file has been enlarged as a result of the updating process.

When data are input by the user from some device such as a keyboard, they are initially stored in the computer's primary memory (RAM). If this same data are then transferred ("output" or "saved") from RAM to secondary storage they have to once again find their way to the correct file on the correct disk in the correct drive. The operating system is also responsible for
informing the user if any problems occurred in the whole process, problems such as damage to a disk or a non-existent file, and so forth.

**Managing the secondary storage medium itself, along with the data stored on it** An important operating system utility we mentioned earlier is called disk optimization. This utility involves telling the operating system to reorganize the files stored on a disk so that they are not split up into sections that are scattered over the surface of the disk. Imagine how long it would take to gather together the contents of a book in a library if each chapter were stored on a different shelf! Likewise it takes the computer longer to find the contents of a file when the file is not all together in one place on a disk.

So disk optimization is the process whereby the operating system gathers together the scattered parts of each file. The benefit of this process is not just a saving in time; it also saves space because it frees up sections of the disk that had become unusable because they were too small. Again, imagine if, in a library, there were lots of small gaps between the books. Each of the gaps would be too small to take a book, but if you were to push all the books up together you would free up large blocks of space into which you could then store more books.

Other disk management tasks that are essential, and therefore common, to all modern operating systems include:
- formatting a disk in preparation for storing data files;
- listing the contents of a disk (often called the directory);
- organizing the files into logical groups of files called subdirectories or folders;
- renaming a file;
- locking and unlocking a file to protect the data by preventing them from being accidentally written over;
- backing up (copying) the contents of a file or an entire disk;
- displaying the contents of a file;
- deleting files.

**Managing the transfer of data between peripheral devices and RAM** A computer system has a wide range of peripheral devices such as keyboards, monitors, printers, scanners, and so forth (Fig. 3.3 on the next page). These are items of hardware that are usually hooked up directly to the system unit of the computer and are therefore under the computer's control. They are often, though not always, located in the periphery of (near or around) the system unit, which is why they are called peripheral devices. In and of themselves they are not essential to a computer's operations. In the very early history of electronic computers there were few, if any, peripheral devices. All data were input and output using either switches on the face of the huge machines or secondary storage media, which in the 1940s meant punched cards. It was not long, however, before other devices were added so as to increase the system's flexibility. Today there is a growing range of such peripheral computer hardware (figure 3.3 next page).

- **Input peripheral devices** Many of these peripherals are used to input data to the computer's primary memory (RAM). Input devices include the keyboard, the mouse, joy sticks, graphics
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pads or tablets, scanners (including bar code scanners in stores), voice recognition devices, touch screens, and the like.

![Diagram of input and output peripheral devices]

Fig. 3.3 Input and Output peripheral devices

- **Output peripheral devices** As illustrated in figure 3.3, another extensive range of peripheral devices is devoted to displaying data that are output from RAM. These include not only the monitor and the printer, of course, but also voice synthesizers, overhead projection systems, sound amplification systems, holographic devices that produce laser-based images, ultrasound imaging systems, and so forth. Notice that these peripherals no longer include secondary storage devices such as disk drives, or cassette tape drives, or CD-R/CD-RW/DVD-R and DVD-RW. As already pointed out, secondary storage is essential to a computer system; peripheral devices are extremely useful, but a computer can manage without them.

Applications programs rely on the basic input/output capability of an operating system whenever it is necessary for the computer to interact with any of these peripheral devices. Thanks to the operating system the applications programmer's job is made easier since the instructions to read data *from* input devices, and to write data *to* output devices is largely taken care of by the operating system.

**Managing computer interaction with communications devices and providing support for communications networks** Advances in computer and communications technologies have...
given rise to a new perception of the computer as a tool for connecting people and data over local and wide area communications networks. In some schools, for example, students are collaborating on projects using e-mail (electronic mail). Students are also using wide area networks connected by the telephone system to log into electronic bulletin boards which enable them to communicate with other students around the world.

Networks are also useful for more mundane tasks such as allowing several computers to share a printer.

Communication between students in different schools, nationally or internationally, is no longer only in the form of text. Devices such as webcams, plugged into the system unit of the computer, enable real time interactive video and sound transmission. Several applications, such as Microsoft's Netmeeting, or Yahoo! Messenger, are making it possible for students to routinely hold internet-based video conferencing sessions with students on the other side of the globe. Cell phones or mobile phones commonly include still image and video capabilities along with internet access for texting and, increasingly, for full access to all the information resources on the World Wide Web. Computer and communications services are merging rapidly as advances in technology emerge.

Communications hardware and software take care of the various rules of the road (called protocols) that have to be observed in order to make a successful connection between different computers on a network. The software to do this is often part of the operating system of a computer and is designed to allow the user to send and receive data, specify protocols (rules for communication to take place between one device and another), and ensure that the data are as error-free as possible. The growing use of networked learning environments will be discussed at length in chapter 7 when we focus on these specialized communications technologies.

Managing the allocation of storage space in RAM to several applications (Multitasking)

Many of the utilities available for your computer system are designed to run in the background while you are busy with other work such as word processing or recording your grades or designing some graphical materials for class. This ability of a computer to handle several programs at the same time is called multitasking.

Multitasking is an important feature of an operating system and it is becoming the norm on all computers today. It allows other utilities (or applications in general, for that matter) to be co-resident in memory, available at the touch of a function key or the click of the mouse button. In other words, you can have several programs open at the same time, even though the computer actually works on only one program at a time.

It does this by allocating tiny slices of time and space (memory) to each task in rapid succession without the user being aware of the complex processing that the operating system has to manage in the background. The operating system divides RAM up into sections or slices, one program per section, and makes sure that the different programs do not interfere with each other as you switch back and forth between them. With the new multiple-core processors, tasks are still running in a time slice, but the cores are running simultaneously.

Fig. 3.4 on page 68 illustrates the power of multitasking. Each of the separate windows on the screen represents a separate task being handled by the computer’s operating system. There are
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several other tasks going on in the background, none of which you can see, but all of which contribute to your productive use of the computer.

Multitasking operating systems give desktop computers the flexibility and potential for user productivity that was once possible only on large mainframe and minicomputer systems just a few years ago.

When we first learn to use a computer, we might be impressed by the speed at which things get done. But it is surprising how soon we adjust to this speed, take it for granted, and then become impatient when the computer makes us wait a few minutes, even a few seconds, as it completes a process that might previously have taken us hours without the computer!

As Piaget (1970) pointed out: "the notion of time is an intellectual construction." We all know how much longer it takes for a kettle to boil when we stand there and watch it. But if we have something else to keep us busy, the kettle boils in no time at all! Likewise, when we use a computer, we might become impatient when a printer seems slow, for example. With a multitasking operating system, we can overcome this "notion" of slowness by being able to get on with some job on the computer while it completes another process in the background, such as sending a file to the printer, recalculating a large spreadsheet, or making a backup copy of your hard drive.

Useful user-controlled operating system functions

For the most part, the operating system takes care of the management tasks described in the previous sections without your needing to be aware of what is going on. There are, of course, many jobs that you may want to do on an ad hoc, spur of the moment, basis. You may want to work with the files on your disks, for example. You may want to change the way your computer is set up (called the configuration of the system) or, more and more today, you may want to change the way you interact with the computer via the graphical user interface, which is the subject of the next section of chapter 3.

THE GRAPHICAL USER INTERFACE (GUI)

The problem of nonstandard user interfaces

Until relatively recently, the way software behaved to the user had little or nothing to do with the operating system. Programs designed to run under early operating systems such as Apple's DOS or Microsoft's MS-DOS behaved very differently from each other, even when they were designed to accomplish the same goal (say graphics or word processing) and to run on the same operating system! Whoever wrote the program—the word processor, the game, the course scheduler, and so on—also had to design and write the instructions to control how the user interacted with the computer. There was no standard method or style of interaction. For every new piece of software that came along, the user had to learn the language of the interface: How do I save files with this software? How do I load a file from disk? How do I name a new file? How do I change a name? How do I tell the computer to do this, that, or the other?

Baudville's Award Maker Plus™, for example, was like a foreign land compared to, say, a program such as Brøderbund's Print Shop™. Users of Word Perfect were lost when it came to
using Word. All were excellent software tools, but one would never know by looking at them that they had been designed for the same operating system running on the same computer. One would experience a kind of culture shock when one made the transition from one software package to the other, and the learning curve would be much steeper than necessary as a result.

Those brave souls who mastered the basics of one or two applications often would not progress beyond this level of computer competency. The steep learning curve quickly exhausted whatever motivation they may have started out with.

And those were the brave souls…

The fact is that, until the last twenty years or so, an inordinately high number of teachers took one look at what was involved in learning to use those early personal computer systems and, not surprisingly, they ran a mile rather than have anything to do with them.

School administrators who recognized the importance of the computer in the educational process, and who made the decision to invest in computer hardware for their schools, had to factor in the added expense of extensive in-service training for the teachers, just so that the teachers could learn how to use the machines and the software—let alone incorporate the technology into the curriculum. Where such training has not been available, the computers have all too often remained idle in classrooms and computer laboratories alike.

So until the 1990s, lack of standardization in the way computers “look and feel”—the user interface—was a major factor inhibiting many teachers from accepting computer technology. Fortunately two innovations have helped significantly in reducing people's phobias: integrated software and the graphical user interface.

**Standardization through integrated software or suites of programs**

To get around the problem of nonstandard user interfaces some software, called integrated software, combines into one program several of the most useful types of application. Microsoft’s Office, the flagship in this regard, combines a word processor, a file manager (database), a spreadsheet, presentation tools, graphics programs for drawing and painting, and communications tools.

As pointed out earlier in this chapter, the authors of this book have prepared and made available, free of charge, sets of tutorials for Microsoft Office (Office 2000, Office XP, Office 2003, and Office 2007), designed especially for teachers to help them learn how to integrate Office into their teaching.

The user interface for software such as this has few surprises because the different applications are closely associated with each other. Commands to copy, delete, move, find, or save data are the same whether one is manipulating text in the word processor, making entries into the database, or calculating values in the spreadsheet. Cutting and pasting data between the different components is also greatly simplified. Consequently the effort invested in learning to use the software is rewarded with easy access to the several applications that make up the suite of programs designed to increase your productivity.
Standardization through Graphical User Interfaces

Integrated software is one approach to standardization, but until the advent of the graphical user interface (GUI) the standardization was still limited to a specific software package. AppleWorks did not look like ClarisWorks or Microsoft Works, for example, and none of them looked like Microsoft Office. An experienced AppleWorks user needed to make a significant adjustment to learn to use ClarisWorks and of course the reverse was also true. Each computing environment—the Apple II, the Apple Macintosh, or the IBM PC—was quite different. But the Graphical User Interface—or GUI, as it is called—has changed all that.

As illustrated in figure 3.4, the key features of GUls are the Windows, Icons, Menus, and Pointers (the components of the so-called WIMP interface) which are now common to all personal computers.

Using the mouse or keyboard commands, the user is able to interact with the computer through these screen-based images which can be selected, opened, closed, browsed, moved around, overlapped, scrolled, and otherwise manipulated.

Once one has learned the basic set of GUI interaction skills, the technicalities of the computer become transparent to the user and the mind is set free to more easily process data and use the
applications. When one uses a GUI-based system the computer no longer gets in the way. Quite the contrary, the GUI invites use with its attractive and consistent mode of interaction.

**Some background history of the GUI**

Not everybody famous is well known. We’ve all heard of Vincent van Gogh, Albert Einstein, and Tiger Woods. But who ever heard of John Vincent Atanasoff, inventor of the electronic digital computer, which is surely a machine that has changed the world? Who ever heard of Douglas Englebart, inventor of the GUI, which made Atanasoff’s computer available to “the rest of us”?

We have already given John Vincent Atanasoff his due. Let us now recognize the work of Doug Englebart.

Fig. 3.5 Dr. Douglas Englebart, inventor of the mouse and other features of the modern GUI

Englebart pioneered early GUIs in the 1960s at Science Research International (SRI) (Metcalf, 1992). He developed the original mouse-based, interactive, networked computing environments. He demonstrated them to his academic colleagues at professional conferences. He was somewhat ahead of his time because the only computers that could handle the demands of his computational ideas had to be the most powerful computers in the world at the time. But, as it turned out and as he foresaw, it was just a matter of time before Englebart’s ideas became the everyday norm.

In the 1970s, his research was taken up by Bill English and Ron Rider at the Xerox Palo Alto Research Center (Xerox PARC). But the GUI that set the tone for the computer industry as a whole was that designed for the Apple *Lisa*, introduced in 1983. The *Lisa* was quickly superseded a year later by Apple's *Macintosh* computer.
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The GUI for these Apple computers was the brainchild of Alan Kay, who had also conducted initial research at Xerox PARC before becoming a research fellow at Apple Computer Inc.

Indeed, it was during a visit to the research facilities at Xerox PARC that Steve Jobs, founder of Apple Computer, Inc., got his first glimpse of a GUI. This was in the late 1970s and the experience led directly to the eventual introduction of the breakthrough GUI Apple Macintosh.

On systems such as the Apple Macintosh, the user interface is part of the operating system. Anyone who writes applications for the Mac must follow the standard conventions (guidelines, as they are called) laid down by the system's designers at Apple Computer, Inc. So all the software for the Mac looks alike; it behaves in a consistent and predictable way. This has made the Mac very much easier to use. It also helped coin the 1984 advertising slogan describing the Mac as "The computer for the rest of us."

The success of the Mac in the marketplace did not go unnoticed by the other computer manufacturers and software developers, especially Paul Allen and Bill Gates at Microsoft Corporation. Several GUIs that reflect the look and feel of the Mac have been developed since 1984. Larger computers—mainframes, minicomputers, and work stations—have adopted XWindows™ or Motif™ which are GUIs for the UNIX™ and Linux operating systems. Microsoft Corporation's Windows products, designed as operating systems for Intel-based PCs, have beaten...
out other GUIs such as *TopView™* and *Presentation Manager™* to become the operating systems of choice for PCs.

Apple tried in vain to claim copyright infringement on their Mac GUI. They fought a six year long legal battle with Microsoft, in the balance of which hung Apple’s survival as anything more than an also-ran in the personal computer marketplace. But in the end Apple failed because, as we now know, the GUI wasn’t really Apple’s idea in the first place.

**GUIs and educational psychology**

The design of the now classic GUI—the so-called WIMP interface with its Windows, Icons, Menus, and Pointers—is based on a study of the process whereby humans learn. As a student of education, you will thus be interested to find out something of the research that led to the development of the Macintosh GUI.

The research team at Apple was headed by Dr. Alan Kay who described his conviction that "whatever user interface design might be, it was solidly intertwined with learning." (Kay, 1990) As already pointed out in this chapter, Kay acknowledged his debt for the ideas that led to the Mac GUI to the work of many individuals, including Doug Englebart and the folks he worked with at Xerox PARC. But he singled out three men in particular because they helped him define the philosophy that drove his design of the Macintosh computer system.

The first was Jean Piaget, surely among the epistemologists best known to students majoring in Education. The second was Seymour Papert, creator of the Logo programming language and a disciple of Piaget. And the third was Jerome Bruner, whose learning theory was also much influenced by the work of Piaget.

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1 Both *TopView* and *Presentation Manager* were developed by IBM.
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We will take a closer look at the work of these and other scholars at various points on our journey through this text. The computing paradigm that Kay formulated was based especially on Bruner's work and is what concerns us here as we study software in general, and computer operating systems in particular.

Bruner (1966) postulated that we have different modes of thought, "multiple separate mentalities" as Kay calls them.

![Dr. Jerome Bruner](image)

*Fig. 3.8 Dr. Jerome Bruner*

The many different ways in which we learn are closely related to the various stages of cognitive development identified by Piaget. Three of these Bruner mentalities—called *enactive, iconic* and *symbolic* by Bruner—Kay interpreted as *doing, imaging, and symbolic* mentalities respectively, from which he formulated his model: "Doing with Images makes Symbols."

When we interact with Apple’s *Macintosh* computer, or with any computer that enables the user to interact via a GUI, we are actively pointing and clicking with the mouse (“doing” in Bruner’s terms), to select from pictures called icons (the "images" on the screen representing objects and operations), in order to carry out some intellectual ("symbolic") activity which extends our mental capabilities and promotes learning.

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1 The classic four stages of cognitive development in children: sensorimotor, pre-operational, logical operations, and formal logical operations stages. The sensorimotor stage corresponds to Bruner’s enactive mentality where children learn essentially non-verbally by playing with and experimenting with the world around them. The pre-operational and logical operations stages correspond to Bruner's iconic mentality, where children use language and pictures to reason about their world. The formal logical operations stage corresponds to Bruner's symbolic mentality, where children and adults are able to think more independently about their world and life in general.
Today, the GUI à la Mac is becoming the norm on all computer systems, including Intel-Windows-based (Wintel) machines. It means that we can look forward to learning new systems and new applications without the struggle that used to accompany making a transition from one computer system to another, or from one application to another.

This is as it should be. Ask the children; they flock to computers as though they were the most natural things in the world.

We should be thankful to people like Doug Englebart, Alan Kay, and their associates, along with the "giants on whose shoulders they stood." They took computing out of the exclusive hands of technicians and made it available to the rest of us.

APPLICATIONS SOFTWARE

As observed earlier in this chapter in the discussion of integrated software and suites of software, five types of computerized applications are widely used in all professions, all walks of life. These include word processing, file or database management, spreadsheets, graphics, and communications. When they are sensibly integrated into the work environment by well-trained and experienced users, these applications are powerful productivity tools. This is as true for the teacher and student in the school as it is for those involved in other professions.

Of course, there are literally hundreds of thousands of other applications—programs designed to help the user use the computer to accomplish some task or other. A growing number of programmers, many teachers among them, are working alone or in teams developing new applications in response to the insatiable demand for software, a demand which only increases as the computers themselves increase in speed and power. The potential is quite simply boundless because of the nature of the computer as a Universal Machine. There is no end in sight to the ways in which the computer can be applied to solve problems and help us complete jobs more efficiently.

In the context of the classroom, applications have been developed to help the teacher teach and the student learn. The terms Computer Managed Instruction (CMI) and Computer Assisted Instruction (CAI) have been coined to describe such systems. Here is a partial listing of different applications of CMI and CAI that are used in schools today.

- **Computer managed instruction (CMI)** is a subject on its own and will be covered in detail in chapter 5. CMI is where the teacher uses software to prepare lesson and unit plans, make and give presentations, keep track of the progress of each individual student in the class with grading software, assessment tools, and other classroom management utilities and applications, and prepare the myriad documents (handouts, ditto masters, and so forth) that are the bread and butter of every teacher’s job.

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1 Sir Isaac Newton is quoted a saying: "If I have seen farther than others, it is because I have stood on the shoulders of giants."
• **Computer-Assisted Instruction (CAI)** includes a huge range of applications where the computer is used to help students learn. Here are some of the types of CAI currently used in schools:

  * **Drill and practice**, which has great value for both routine and remedial learning by providing computer-generated and computer-assessed repetitive practice of previously learned subject matter.

  * **Tutorials**, which enable students to learn new material at their own pace. The World Wide Web is becoming a rich resource for such online learning opportunities. Tutorials are also available on CD-ROM.

  * **Simulations**, where students experience a slice of "real" life in the "virtual" reality of programmed worlds, available on the Internet or on CD-ROM. DVD, often in the format of video games.

  * **Microcomputer-Based Laboratories (MBLs)**, also called Computer-based Laboratories or CBLs, in which children conduct science experiments where the computer is a key tool in the collection and visualization of data.

  * **Collaborative learning**, where students use the computer to coordinate their efforts as a team towards some educational goal designated by their teacher.

  * **Communications and Distance learning**, where networks of computers linked by telephone communications enable students to attend classes from remote sites distributed around a region or even around the globe.

  * **Multimedia applications**, where students and teachers use interactive video, sound, graphics and text combined in a symphony of modalities to produce presentations and learning modules that are rich in intellectual stimulation.

  * **Game and role playing applications**, where students learn as they play. This is especially valuable for learning with younger children, though even older students and adults enjoy learning while they play, too!

In chapters 5 through 10 we will examine these CMI and CAI application areas in more detail.

**LOOKING BACK**

Chapters 2 and 3 have covered the fundamentals of computing. Think of this material on hardware and software as the foundation for what is to follow. The better you understand these fundamentals the more effective control you will have over the mechanics, the nuts and bolts, of computer use. Understanding how computers work will free you to take better advantage of the computer as a tool for teaching and learning.

There is a culture that surrounds the use of computers. Those who have become acculturated tend to save their work more frequently; they hesitate before pressing certain keys, depending on the software they are using; they handle disks carefully; they exit from software by closing files and shutting down the program before turning off the machine; they are not unduly surprised when the
hardware or software fails because they routinely backup their work; and so forth. They have learned to accommodate the idiosyncrasies of computers, these dumb machines. That is all they are, after all.

The software that controls computers is only as good as the people who create it and the people who use it. One way or another, that means you.

LOOKING FORWARD

Going forward, it will be useful to examine the key features of each of the different types of applications software overviewed in this chapter, and at the same time discuss how they can be effectively integrated into the learning process. This will be the subject of chapters 5 through 10.

But first, in chapter 4, we will discuss different strategies for setting up educational computing environments. This is an important issue because too often schools just buy computer hardware and software and dump it into a classroom without sufficient consideration for what works best in terms of computer integrated teaching and learning. Chapter 4 is an important discussion of the issues involved in successful integration of computers into K-12 education.

In chapter 5, we will examine software that is useful to the teacher for the purpose of managing the instructional process.

Chapter 6 will survey the various types of software designed with the students' learning needs in mind: software for productivity, drill and practice, tutorials, distance learning, multimedia, simulations, and so forth.

In chapters 7 and 8 we will examine electronic communications and reflect upon the present and probable future impact on schools and schooling of the burgeoning global network of networks called the Internet.

Chapter 9 will take a practical look at the tools involved with internet-enabled online learning.

Chapter 10 is all about computer-based multimedia. We will discuss learning systems that have emerged in the last few years which take advantage of the integration of audio-visual materials with computer control.

In chapter 11 we will discuss software development. The challenge of creating quality software applications is not for the faint-hearted, but understanding the nature of that challenge will help you appreciate the talent of the people who create the software that you use. Perhaps you will even be bitten by the programming/authoring bug yourself.

For the most part, however, schools must pay for the hardware and software for computer-integrated learning. This does not come cheap, but plenty of money is available if you know how to get your hands on it. Chapter 12 looks at everything involved in fundraising in general, and grant writing in particular—that’s the process of writing proposals to raise money from foundations and other sources of funds. This includes learning where to apply for money, how to apply for it, and what to do with the money once it has been won.

Computers are having a dramatic effect on our world. They are changing the way we live and work. They are also changing the way we learn. Advances in technology enabled by
computerization are also causing us to confront new ethical and legal issues. Chapter 13 will provide an opportunity to read about, and reflect upon, these more philosophical topics in order to heighten the reader's awareness of the social issues that are raised.

One of the most promising benefits of computer-based learning is that it gives children control of their own learning. The pedagogical implications of this will be discussed in chapter 14 against the backdrop of educational theory.
LEARNING OUTCOMES

Ergonomics is "an applied science that coordinates the design of devices, systems, and physical working conditions with the capacities and requirements of the worker" (Webster's, 1991). Another name for this science is human factors engineering. Human factors are becoming more critical for students as computer use in schools increases. It is quite possible in the near future that students will spend a large part of a school day at a computer workstation. For this reason, comfort, along with health and safety considerations, which are what ergonomics is all about, should be factored into the design of the educational workplace.

It is ironic that educators, of all people, often give little consideration to pedagogy and ergonomics when considering the integration of computer-based technology into teaching and learning. Decisions about what types of computers to buy, how to situate desktop computers in a classroom, where and how to set up monitors, what software to use, how to network the computers together, and whether to network them at all often are made too quickly and without concern for the effectiveness on learning outcomes of the installation plan. As a result, much potentially exciting change is compromised and, when expected outcomes don't occur, further initiatives discouraged.

Expediency is often the primary rationale for decision-making. How many electrical outlets are actually in the proposed computer laboratory (as opposed to how many should there be)? Where are the electrical outlets placed around the room (as opposed to where should they be placed)? How many children will need to be accommodated in the room at one time (as opposed to how many children should be accommodated at one time)? How many tables and chairs will therefore be needed in the room (as opposed to what type of tables and chairs will be needed in the room)? How many computers can fit on the tables in the room where a lab is to be set up (as opposed to how many computers should fit on those tables)?

There are constraints in the design of anything. But constraints should not control design. Good design works around constraints to achieve a system's goals, whatever they may be. Unfortunately, the scenario all too often is the other way around and goes like this:
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"Here is the room, here are the electrical outlets, here is the number of children we need to be able to get in there at any one time—can the room be used for the proposed laboratory?"

"Sure. No Problem."

"Then get on with it. Do what you have to do. Make it work!"

Too often, the needs of administration come first; the needs of teachers and children are an afterthought. It is almost as if there is a policy which says: "We will provide a quality education for the children provided it suits administration’s needs."

Wrong!

Time out...

Let's think about this...

Teachers should always, always be involved in decisions about the learning environment. Their training and experience qualifies them better than most to understand children's learning needs. This assumes, of course, that we're talking about teachers who have graduated from a quality teacher education program. In some, mercifully few, states of the United States, if you have a high school diploma, you are considered qualified to take over a classroom as a substitute teacher! But this is the exception that proves the rule: throughout the United States, most every teacher is well prepared to help children learn what they need to know to cope with life in an information age.

In the best school districts, teachers are included in the dialog about quality K-12 education. Parents and students, too, are involved in decisions about the learning environment. Certainly, it is important to plan for optimal use of computer-based technology. The best planning draws on knowledge and experience. It makes sense, therefore, that the people who have had training or experience in the use of technology, whether administrators, teachers, parents, or students should make decisions about its integration into the curriculum.

This brings up the fundamental importance of career-long training for teachers and administrators, especially in today's world where, as Toffler (1970) pointed out almost forty years ago, change is occurring at an accelerating rate. Just like any other institution, schools must be ready to adapt in response to the needs of an ever-changing world.

This chapter thus examines the criteria that should govern the design of environments for computer-based teaching and learning. In particular we will focus on the following topics.

- First Things First: On-going Training for the Teachers
  - ISTE Educational Technology Foundations for Teachers
- Safety First: Computers and Health
  - Extremely low frequency (ELF) electronic emissions
  - Carpal tunnel syndrome (CTS)
  - Ergonomics to the rescue
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- Other ergonomics-related considerations
- Summary of safety and ergonomics recommendations
- Computer Setup
  - Computers in the classroom
  - The planning, design, and management of the computer lab or multiple-computer classroom
  - Recommendations for lab management

INTRODUCTION

It is interesting, in the context of learning, to think of the computer as a Montessorian device.

"The best teachers," Dr. Maria Montessori (1870-1952) averred, "establish an environment in which expected outcomes occur spontaneously." The success of Montessori schools relies on what Dr. Montessori called the "prepared environment in which the child, set free from unique adult intervention, can live its life according to the laws of its development" (Standing, 1962). Montessori children are encouraged to learn by interaction with the objects in an environment that has been carefully prepared to foster learning on the part of students with minimal interference from teachers.

Montessori went so far as to say: "The greatest sign of success for a teacher is to be able to say, 'The children are now working as if I did not exist.'" And let us not forget that Montessori, during her life time, directed schools for children of all ages, including high school.
Directors of Montessori schools worldwide attest to the fact that children have a spontaneous interest in purposeful mental and physical activity when the appropriate environment is prepared. This includes contemporary variations of the set of didactic materials designed by Dr. Montessori to stimulate "the spontaneous interest of the children as the mainspring of their work" (Standing, 1962).

The task in teaching is thus to supply and maintain that "appropriate environment" that will function as fertile ground for children's growth as fully rounded individuals.

The famous American educationist John Dewey, who, coincidentally, died the same year as Maria Montessori, made much of the importance of child-centered learning where education comes about through discovery of knowledge from doing—whether the doing be artistic, scientific, athletic, or otherwise.

Dewey (1956) reinforces this idea when he describes the experience of a child discovering through doing.

Since really to satisfy an impulse or interest means to work it out, and working it out involves running up against obstacles, becoming acquainted with materials, exercising ingenuity, patience, persistence, alertness, it of necessity involves discipline—ordering or power—and supplies knowledge. Take the example of the little child who wants to make a box... If the child realizes his instinct and makes the

Fig. 4.2 Dr. John Dewey (1859-1952)
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box, there is plenty of opportunity to gain discipline and perseverance, to exercise effort in overcoming obstacles, and to attain as well a great deal of information.

Dewey and Montessori, among other educationists, anticipated the constructivist philosophy of learning which Nickerson (1988) defined thus: "Learning is best described not as a process of assimilating knowledge but as one of constructing mental models. The learner's role is seen as necessarily an active one. It is questionable whether there is such a thing as passive learning. If new information is to be retained it must be related to existing knowledge actively in an integrative way" (emphasis added).

Merrill (1990) further strengthens the link to Montessori/Dewyian/Constructivist methodologies by emphasizing that "the most adaptive teachers are those who have previously prepared a wide variety of alternative learning activities that they can call upon when evidence of misunderstanding appears."

The Montessori model, while not recognized as mainstream, has been successfully applied, knowingly or unknowingly, in many ostensibly traditional schools. Good teachers, often in spite of straightened circumstances in the classroom, go out of their way to individualize instruction. Good teachers give their students the freedom to discover knowledge by preparing classes that will stimulate curiosity, capture attention, and promote a love of learning.

Good teachers also are those most likely to intuitively recognize the power of well-designed and integrated computer-based teaching and learning.

Denise Ryan (1998) observes that the computer is in and of itself "another manipulative" for helping students learn. Merrill (1990), speaking of computer-based interactive learning, recognizes the advantages of technology in education, observing "that interactive environments can be made even more adaptive because a wider range of alternatives can be made available, and a more individual and systematic assessment of misunderstanding is possible."

The computer is a useful medium for putting the child into an artificial world where experimentation can take place, limited only by the availability of the appropriate software and hardware. "Everything that we do on a computer is a simulation," observes Dr. Alan Kay (Elmer-Dewitt, 1991). In fact, the computer can be programmed to simulate virtually any reality, hence the growing interest in "virtual reality" systems.

As such, it seems reasonable that computer-based learning systems should be used to simulate and extend the set of didactic materials designed by such great educationists as Maria Montessori. Imagine a lesson about volcanoes where the teacher's own knowledge and experience are augmented by the child's ability to read and talk about the lesson, all in the context of a computer-based interactive simulation of volcanic activity using multimedia. Imagine a lesson on the romantic poets where the teacher's own knowledge and experience are augmented by reading the poetry and discussing it, against a sociological, historical, and biographical backcloth based on video clips of the lives of Wordsworth or Keats set in the context of 19th century England.
None of these ideas is new. Teachers have always been innovative in making learning exciting. "Go to the place where the thing you wish to know is native," Johann Wolfgang von Goethe observed; "your best teacher is there. Where the thing you wish to know is so dominant that you must breathe its very atmosphere, there teaching is most thorough, and learning is most easy. You acquire a language most readily in the country where it is spoken; you study mineralogy best among miners; and so with everything else."

Networked or standalone computer-based technology, ideally "bundled with the teacher," as Netiva Caftori (1994) reminds us, puts an increasingly rich resource into both teachers' and students' hands, a resource where children can discover for themselves that which they "wish to know."

**FIRST THINGS FIRST: ON-GOING TRAINING FOR THE TEACHERS**

Training is important throughout a teacher's career. This is no less true today, when teaching appears to be on the brink of radical transformation as a result of the infusion of computing technology into schools. The task of making the transition from traditional teaching to teaching with technology is much tougher than it seems. This is because the transition is as much a cultural one as one of mere methodologies. It involves a shift in teaching paradigms, a shift in the way of thinking about teaching.

This shift, away from the teacher as imparter of learning to the teacher as facilitator of learning, demands a great deal of curriculum rethinking and redesign as well as the learning of new methodologies vis-à-vis the use of computer-based technologies in the classroom. One teacher put it this way: "We're all philosophically committed to this, but it has involved so much work, we're barely keeping our heads above water. We have spent a massive amount of time in rethinking things and rewriting courses."

**ISTE Educational Technology Foundations for Teachers**

What is the set of technology skills a teacher is expected to acquire, and what concepts should be learned in order to be able to function effectively as a teacher in schools today?

The International Society for Technology in Education (ISTE) is the world's largest not-for-profit professional organization supporting computer-using educators. ISTE endorses the belief that "computer-related technology must become a tool that students and teachers use routinely if students are to be adequately prepared for adult citizenship in our Information Age society" (ISTE, 1992).

For this reason, the society has spearheaded the National Educational Technology Standards (NETS) project "to enable stakeholders in PreK-12 education to develop national standards for educational uses of technology that facilitate school improvement in the United States. The NETS Project works to define standards for students, integrating curriculum technology, technology support, and standards for student assessment and evaluation of technology use."
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ISTE's published standards\(^1\) include a listing of the National Educational Technology Foundations for All Teachers, called “NETS for Teachers.” The full set of ISTE's educational technology foundations for teachers may be found at the following web URL:


These foundational concepts and skills should underpin the studies that prepare teachers to teach in the modern, computerized classroom. Teachers cannot be expected to use computer-based learning systems effectively unless they acquire the skills and assimilate the concepts that will guide their thinking as they prepare unit and lesson plans for the classroom of tomorrow where technology will be integral to the whole process of teaching and learning.

For readers who do not have ready access to the web, here is the full set of NETS for Teachers. Carefully consider each item in relation to your own readiness to integrate modern, computer-based technologies into your teaching.

1. **Facilitate and Inspire Student Learning and Creativity**

   Teachers use their knowledge of subject matter, teaching and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments. Teachers:

   a. promote, support, and model creative and innovative thinking and inventiveness.
   b. engage students in exploring real-world issues and solving authentic problems using digital tools and resources.
   c. promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes.
   d. model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments.

2. **Design and Develop Digital-Age Learning Experiences and Assessments**

   Teachers design, develop, and evaluate authentic learning experiences and assessment incorporating contemporary tools and resources to maximize content learning in context and to develop the knowledge, skills, and attitudes identified in the NETS•S. Teachers:

   a. design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity.
   b. develop technology-enriched learning environments that enable all students to pursue their individual curiosities and become active participants in setting their

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\(^1\) The society's publications, ISTE Update, The Computing Teacher, and Journal of Research on Computing in Education, are listed in Appendix B.
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own educational goals, managing their own learning, and assessing their own progress.

c. customize and personalize learning activities to address students' diverse learning styles, working strategies, and abilities using digital tools and resources.

d. provide students with multiple and varied formative and summative assessments aligned with content and technology standards and use resulting data to inform learning and teaching.

3. Model Digital-Age Work and Learning
Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society. Teachers:

a. demonstrate fluency in technology systems and the transfer of current knowledge to new technologies and situations.

b. collaborate with students, peers, parents, and community members using digital tools and resources to support student success and innovation.

c. communicate relevant information and ideas effectively to students, parents, and peers using a variety of digital-age media and formats.

d. model and facilitate effective use of current and emerging digital tools to locate, analyze, evaluate, and use information resources to support research and learning.

4. Promote and Model Digital Citizenship and Responsibility
Teachers understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behavior in their professional practices. Teachers:

a. advocate, model, and teach safe, legal, and ethical use of digital information and technology, including respect for copyright, intellectual property, and the appropriate documentation of sources.

b. address the diverse needs of all learners by using learner-centered strategies providing equitable access to appropriate digital tools and resources.

c. promote and model digital etiquette and responsible social interactions related to the use of technology and information.

d. develop and model cultural understanding and global awareness by engaging with colleagues and students of other cultures using digital-age communication and collaboration tools.

5. Engage in Professional Growth and Leadership
Teachers continuously improve their professional practice, model lifelong learning, and exhibit leadership in their school and professional community by promoting and demonstrating the effective use of digital tools and resources. Teachers:
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a. participate in local and global learning communities to explore creative applications of technology to improve student learning.

b. exhibit leadership by demonstrating a vision of technology infusion, participating in shared decision making and community building, and developing the leadership and technology skills of others.

c. evaluate and reflect on current research and professional practice on a regular basis to make effective use of existing and emerging digital tools and resources in support of student learning.

d. contribute to the effectiveness, vitality, and self-renewal of the teaching profession and of their school and community.

Courses in educational technology for undergraduate education majors should reinforce all these foundational skills and concepts. Ideally, education majors should experience technology-integrated learning across the curriculum as part and parcel of all Methods courses and other programs of professional development.

SAFETY FIRST: COMPUTERS AND HEALTH

Administrators and teachers need to know about health and safety issues with computers because they control how the technology is set up and used. But students should also be taught correct use of technology because they will be using it throughout their working lives. Health issues are especially significant. Computers and related electronic systems can cause debilitating, even life threatening, illness when used incorrectly. These issues are being discussed more and more in the media as we become aware of the cumulative effects of long-term exposure to, or use of, these ubiquitous machines.

Extremely Low Frequency (ELF) Electronic Emissions

All electrical devices emit electromagnetic radiation. These extremely low frequency (ELF) emissions are for the most part harmless. Extensive research has turned up no significant adverse effects from normal exposure to ELF emissions, such as those that are produced by most electronic equipment in the home. Display terminals—televisions, computer monitors, video display terminals (VDTs), or cathode ray tubes (CRTs)—are a different story, notwithstanding the conclusions of the Center for Office Technology referenced in Hagar (1991).

Although no conclusive connection has yet been established between ELF emissions and various side effects harmful to health, several U.S. and European studies offer support for some level of concern, according to Branscum (1991) and O’Connor (1991). Suspected side effects of ELF emissions are leukemia, breast cancer (male and female), testicular cancer (especially in the case of troopers who have been accustomed to resting radar speed-detection devices in their laps when on traffic duty), and miscarriage in pregnant
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women. Branscum cites an Office of Technology Assessment report that "suggests taking a ‘prudent avoidance’ strategy to minimize any potential risk."

In the interests of safety, the following recommendations should be implemented in any school, home, or office computing environment:

- Position computer monitors so that users can sit at least an adult arm's length (two to three feet) from the screen.

- Maintain similarly adequate distance from the sides and back of other adjacent computing machines, especially since the sides and back of electronic machines are not required to be shielded to reduce the amount of ELF emissions released.

The standard recommended minimum depth for computer tables, by the way, is 30 inches (Apple Computer, 1991). A table with a depth of less than 30 inches or so cannot allow adequate distance between the user and the monitor screen even when the keyboard is on a separate tray. We will return to these issues later.

**Carpal Tunnel Syndrome (CTS)**

Carpal tunnel syndrome (CTS) is a type of repetitive stress injury (RSI) that affects at least the hand, wrist, and forearm as a result of an inflamed ligament that presses on a nerve in the wrist, where the carpal bones are located (Fig. 4.3).

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Figure 4.3 Carpal tunnel syndrome (CTS)

Photo courtesy United States National Library of Medicine, National Institutes of Health
Pain, numbness, and/or tingling sensations occur in the thumb and fingers and can also shoot up the forearm. In some cases, the pain can extend to the upper arm, shoulder, and upper back. It can be debilitating, to say the least.

One cause of CTS is relentless repetition of work at a keyboard (or mouse). It is more likely to occur when using a computer (as opposed to a typewriter) because the computer is a more engrossing medium per se. It is not unusual to work continuously at a computer keyboard without changing the basic position of the hands; the fingers just hammer away for hours. At least with an old-fashioned typewriter the user had to stop typing at the end of every line to return the carriage that holds the paper, and then again every few minutes in order to put a new piece of paper in the machine. Of course, even typists used to fall victim to CTS. But since they were mostly women, no one paid particular attention to the suffering they had to endure. Some say that it is only since men started using computers during their workday that CTS has been recognized as a problem at all!

The computer has brought about changes in the nature of people's jobs. An increasingly large percentage of workers use a computer keyboard for a significant proportion of their workday. Many take their work home, and continue to type away there. Not surprisingly, there has been a consequent increase in the reported cases of RSI, mostly attributable to the increase in CTS. According to U.S. Department of Labor statistics, in 1992 half of all workplace injuries were related to RSI as compared with only one fifth in 1980 (Adler, 1992).

For a comprehensive and up-to-date fact sheet about CTS, you can go to the following web site maintained by the National Institute of Neurological Disorders and Stroke: http://www.ninds.nih.gov/health_and_medical/pubs/carpal_tunnel.htm.

Ergonomics to the rescue

Ergonomics is "an applied science that coordinates the design of devices, systems, and physical working conditions with the capacities and requirements of the worker" (Webster's, 1991). Another name for this science is human factors engineering. Human factors are becoming more critical for students as computer use in schools increases. It is quite possible in the near future that students will spend a large part of a school day at a computer workstation. For this reason, comfort, along with health and safety considerations, which are what ergonomics is all about, will have to be factored into the design of the learning environment.

There are several ways of preventing keyboarding-induced CTS. Adler (1992) profiles some revolutionary alternative keyboard designs that enable the hands to assume a more natural, unstrained position while typing. One design, for example, literally breaks the keyboard in two so that it takes on the shape of a shallow "V" (Fig. 4.4 on the next page).
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Fig. 4.4 Microsoft’s ergonomic keyboard design

Using this keyboard the hands can maintain a more natural position. But it will be a long time before such devices replace the traditional keyboard—unless the law gets in on the act.

Gannett (1992) reported that "U.S. District Court Judge Jack Weinstein of New York has consolidated 44 lawsuits against AT&T, Apple Computer, IBM, Northern Telecom and other technology companies" because of what are claimed to be design flaws in computer keyboards that are responsible for hand injuries such as CTS. Ideally it is best to avoid an injury in the first place, and this is possible with the application of elementary ergonomic adjustments to furniture and to one's daily work routines.

Take a break Since CTS is caused by relentless repetitive activity over long periods of time, breaks from the keyboard should be taken frequently—every half hour or so. Utility programs have been developed to address this need. The software, which runs in the background while the user is busy at some computer-related task, makes an audible beep and puts a message on the screen every half hour or so to remind the user to take a break. With speech synthesizers built into more and more computers, there is no reason why the computer could not be programmed to put the reminder into words: "Why don't you take a break, my friend."

Support the wrist The wrist should be supported in some way or another. Figure 4.4 above illustrates an example of a wrist rest. There are many other types of wrist rest which help to maintain correct wrist position while typing.

Just work naturally Stephanie Brown, a concert pianist and teacher in New York, likes to quote her Russian music teacher when she gives advice on how to avoid RSI at the piano or computer keyboard. "Just play naturally," the Russian teacher told her. Brown now teaches her methodology to anyone who wants to listen, including "insurers, physicians, patients, physical therapists, and corporate attorneys" (Associated Press, 1996).

The methodology involves encouraging the "patient"—computer user, musician, or whoever is vulnerable to repetitive stress injury—to find the natural position of the hands or arms. Beginning "hands off," the user moves back from the keyboard and relaxes the hands and arms. The idea is to find the most comfortable position possible.
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This is often with the hands and forearms resting in the lap. With this awareness in mind, the user can then return to the keyboard, where he or she learns to sense discomfort early, and to seek the most comfortable position as frequently as necessary in order to avoid the long term disability that would otherwise come with repetitive stress.

This would be a useful exercise to conduct with one's colleagues and students, and is recommended in the DO SOMETHING ABOUT IT section at the end of this chapter.

**Rotate jobs** A further measure might be to assign workers (and students) to a variety of tasks so as to break up the day with different types of work. Activities should be rotated among a group or team of people so that no one individual has to work at the keyboard for days or weeks on end. Today, more than ever, because of the proliferation of computers in the workplace (and soon in schools, too), many people are chained to a keyboard five or six days a week, fifty weeks a year, for their entire careers. No wonder there is a dramatic increase in the number of reported cases of CTS.

**Other Ergonomics-Related Considerations**

**Keep work habits flexible and varied** Ergonomics has as much to do with the culture of the workplace (or study-place) as with physical comfort. When people talk about ergonomics they most often refer to physical things such as the design of furniture, the levels and type of lighting, or the levels of noise in an environment. These are important considerations when designing working conditions in which people can be maximally productive, and we will examine them more closely. But Hagar (1991) points out that people's behavior patterns when using machinery, for computing or otherwise, also contribute to their physical and emotional problems on the job.

The problem is that the human anatomy stiffens up as a result of extended periods in a fixed position. The computer is an unusual machine in the sense that it demands relatively little overall body movement. At the same time, the items displayed on the computer monitor tend to focus concentration to such an extent that the user often does not notice the passage of time. Hours become condensed into what seem like minutes.

Turkle (1984) reminds us of this “holding power” of the computer. This is most likely to happen when the mind is at the same time engaged in a high level of concentration. In this respect a computer is not unlike a car. During a long, unbroken stretch of driving we do not notice that our body is getting stiff (seizing up?) until we stop and try to slide gracefully out of the vehicle—ouch!

When we work at computers, we should do what sensible people do on a long trip: stop frequently, stretch our legs, get some fresh air. There was a time when we used to make fun of the Japanese because they would be shown doing calisthenics in the office during the workday. Now we know that they had more sense than we were prepared to give them credit for.

More and more American companies encourage workers to vary their working schedules. Some companies are even providing exercise facilities for aerobics and so
forth. These cultural changes are predicated on the belief that a sound body and a healthy mind lead to greater physical and intellectual productivity which, in the workplace, translate into increased profits and, in the classroom, into better learning.

**Create the right ambiance** Ambiance covers everything from space, to lighting, to noise levels, and to colors of everything from wall and floor coverings to furniture. Computer labs are often cold, cramped, cluttered environments. A few simple and relatively inexpensive enhancements can significantly improve the comfort for users and increase their productivity.

Lighting should be subdued and localized so as to cut down on eye strain and headache-inducing glare from the computer screen. Noise should be muted by sound-absorbing floor, wall, and ceiling materials. Colors of walls and ceilings should be neutral (light pastel shades). All surfaces should be non-reflective.

The more space for movement around a classroom the better. This reduces stress, both physically and psychologically. People also work better when they have “room to breathe,” so to speak. Usually, very little consideration is given to how to optimize the space in a room so that open space is maximized. It is surprising how much space can be gained through careful placement of furniture. The simplest technique for doing this is to use a scaled-down model or floor-plan of a room with cut-out shapes of all the furniture that will go in there. Then try any number of options for positioning the objects in the room until the maximum amount of open space is made available. Applying this idea will help avoid stereotypical layouts such as rows, too.

A valuable team-building idea is to make a competition or an assignment out of designing the best layouts for classrooms or computer labs. This is recommended as an assignment in the DO SOMETHING ABOUT IT section at the end of the chapter.

**Use ergonomics when setting up standard computer equipment** The footprint of a machine is the amount of space it takes up on a table top or floor. Ideally, the footprint of the standard components of a computer system should take up no more space than the footprint of the monitor. The monitor also should be tilt-able so that users can tilt the top of the monitor away slightly—this can also be useful to reduce glare.

Printers should not be located on the workstation table top. Sometimes they are stacked above the monitor, on a stand, but this arrangement usually makes access difficult when it is necessary to adjust printer settings and insert and remove paper, especially for small children. Ideally, the printer—especially if it is a noisy dot matrix printer—should be located somewhere out of the way. This is important in a lab environment where desk top space is usually at a premium. Modern networked environments need only one or two relatively inexpensive, quiet, high speed laser printers to serve the needs of a labful of users.

The keyboard, which is usually connected by a cable to the system unit, should be capable of being moved around independently of the system unit. A wireless keyboard and mouse would be the ideal since there would be no wiring straggling across the surface of the workstation table top and getting caught up in other equipment. Whether
or not wireless keyboards and mice (mouses?) become standard in schools remains to be seen. After all, they would more easily "run away" if not tethered to the machine!

The special extra equipment for multimedia systems—scanners, laser disc players, CD-ROM drives, large screen high resolution monitors—should also be mounted on mobile units so that they can be shuttled from classroom to classroom or, if they belong in one room, so that they can be moved to a convenient location in the room when they need to be used by the students or the teacher and out of the way when not. We will discuss multimedia equipment in more detail in chapter 9.

Select or adapt furniture to fit the user Workstation tables and chairs should fit the person using them; to this end, they should come in different heights and also be adjustable. In particular, the following should be kept in mind when selecting tables or chairs in a computing situation.

Tables A computer table should large enough to accommodate the computer while leaving room for ample workspace on either side of the computer.

Ankrum (1993) presents research spanning the last 50 years which shows that eyestrain induced by extended work at a computer can be significantly reduced if one sits at an optimal distance (about 30 inches—or about an average adult arm's length) from the computer screen and if the screen itself is in a relatively low position compared to what is normally the case when computer monitors are placed on table tops. Ankrum makes a strong case for embedding the computer monitor below a glass-surfaced table top or desk. This configuration is common today in TV studios.

Ankrum (Nova, 1993) points out that this design is not only ergonomic. It is also more effective in other ways. It saves space by freeing up the table top for work; it simplifies the management of wires, which do not have to be tracked away from the table top and can more easily be concealed both from view and from accidental damage; and it helps secure privacy by concealing the screen from prying eyes.

Chairs Chairs that are adjustable for height allow the user to position the top edge of the computer monitor below eye level—an optimal position. But chairs should be adjustable for reasons other than height.

The back rest should also be adjustable so that it can support the lower and middle back and help the user maintain a relaxed, upright position. An adjustable footrest would be useful, especially with small children using desks and chairs that are too high for them. A person’s legs should not be allowed to dangle unsupported for long periods since, over time, this can lead to injury at the back of the knees and upper legs.

Some teachers worry about children misbehaving with chairs that are adjustable or that have wheels on them. First of all, the teacher should have class management skills that will obviate indiscipline. But, if a student does misbehave by way of “chair abuse”, the teacher can always have handy a simple, cushion-free, relatively uncomfortable cafeteria-style chair to offer miscreants!
When using the mouse, all of the wrist and much of the forearm should be able to rest—without over-extension of the arm—on a supporting surface such as a wide, ideally padded, chair arm or the table top so that the upper arm hangs naturally close to the side of the body on which the mouse is used (not excessively off to one side or reaching out in front of the body). This will reduce strain on the upper arm, shoulder, and upper back.

Discomfort, perhaps even chronic pain, will result when the only room for the mouse pad is either too far to one side of the body. In such a configuration the upper arm, shoulder, and upper back will soon start to feel the strain when the arm is suspended unsupported for long periods of time.

**Summary of Safety and Ergonomics Recommendations**

Our focus in this book is on the computer, so, to summarize, here are some inexpensive and highly effective recommendations for maintaining ergonomically-correct computing environments in schools. Some of the recommendations are adapted from Hagar (1991).

- Provide chairs that can be adjusted for height so that users can position the top edge of the computer monitor at, or slightly below, eye level. This encourages users to hold the head in a comfortable upright position, thus taking pressure off the neck and upper back.
- The chairs should have adjustable back rests for support of the lower and middle back.
- The optimal background color for reading text is white. This reduces eye strain. So when preparing learning materials that will be shown on the screen, teachers should make the background of such displays white.
- Tilt the screen (with wedges if necessary) to cut glare from natural or artificial light sources in the room.
- Computer keyboards should be detachable so that the user can sit back from the monitor and also adjust the orientation of the keyboard for maximum comfort.
- Keyboards should be adjustable for height so as to fit the position of the arm and wrist, which will vary from person to person.
- Put some kind of padding along the front edge of the keyboard and the mouse, on which the user's wrists can rest. Folded up toweling will do for this purpose.
- Use tables that are deep enough to allow the user to be at least an adult arm's length from the computer monitor. This reduces the risk of side effects from ELF electronic emissions.
- The tables should be large enough to provide adequate work space for writing and other activities.
- Use non-reflective and sound-proofed materials for all surfaces in the room to cut down on glare and noise.
Chapter 4: Educational Computing Environments

- Use neutral colors for surfaces and equipment to create a restful ambiance for the eye.

**COMPUTER SETUP**

Selfe (1992) points out that the introduction of computers in schools through the 1980s and early 1990s was often poorly planned without consideration for the pedagogical and logistical problems. Her immediate concern was the retrograde effect this has had on the teaching of writing, but the problems apply across the curriculum. What are the most common scenarios when it comes to computers in the classroom in today’s K-12 schools?

There are at least five paradigms to bear in mind. First there is the classroom which has no computers at all, not even for the teacher. Computers will still factor into lesson planning by the teacher because there are internet-ready computers in the community and/or in the students’ homes, but clearly there are no issues to be considered with regard to how computers are set up in the classroom.

Next there is the one-computer classroom, where the computer is one teaching/learning tool amongst others, such as the overhead projector and the chalkboard. Ideally, in this case, the computer will be relatively up-to-date, on-line to the internet, and connected to a large screen TV or other projection device for presentation to the class as a whole.

The third paradigm for computing in schools is where you have a cluster of computers (5 or 6) in the classroom. Once again, these computers hopefully will be relatively up-to-date and on-line to the internet. The teacher will have a computer, too, as in the one-computer classroom, on-line to the internet and connected to a large screen TV or some other projection device for presentation to the class as a whole.

A fourth paradigm for computing in schools that is very common today is where you have a computer laboratory used by the teacher who wants the whole class to work on computer-based projects, together or in groups and at the same time.

A fifth paradigm has emerged in the last few years but is still relatively rare. This is where every student in a school has a personal laptop computer with wireless internet connectivity both at home and at school. The day is fast approaching when this paradigm will be the norm for all students.

Let us examine the last four of these paradigms a little more closely along with several other issues that are often overlooked when introducing computers into the learning environment, whether that environment be the classroom, the computer lab, or the home.

**Computers in the Classroom**

Every school at one time or another has debated whether to put computers in classrooms or in labs. Arguments against computers in the classroom are that they are expensive resources that are underutilized. When they are clustered in a laboratory setting, they can be scheduled for use by all classes, and actually are used in many cases all day everyday of the week.
Chapter 4: Educational Computing Environments

This discussion is slowly but surely becoming moot as more and more schools have introduced clusters of computers into every classroom AND have one or two computing laboratories for whole class computing or computer-based instruction.

In the rest of this section we will focus on the set up for computers in the classroom. Then in the following section we will consider issues that arise when setting up and maintaining a computer lab.

One computer, one classroom The safety first recommendations discussed earlier in this chapter should be applied as far as possible, no matter what the computing environment. If they cannot all be applied, your students should at least be told about them. They are an important aspect of computer literacy which is often neglected. Use the computer to make posters displaying the relevant safety and ergonomics-related recommendations, and periodically go over them with students. Better yet, each year start out with a project where your students make up new posters covering all the ergonomics and safety-first bases surrounding the installation and use of technology in their classroom.

The following are some strategies which will optimize the use of a computer in the one-computer classroom:

- Set up the computer equipment on a mobile table or cart so that it can be moved easily from one part of the room to another. Sometimes you may want to use it in a front, central location in conjunction with an overhead projector. Other times you may want to put it at the back of the class where a project group can work on it while you are busy with the rest of the class. You should be careful to stow the projector along with its cable in a safe place after use.

- The more you use the computer, the better. Like any machine, a computer suffers from lack of use. When not in use, however, it should be covered to keep out dust. The teacher shouldn't need to take care of this. Appoint a student for the task!

- Use a splitter cable (a "T" or "Y" adapter) to enable the output from the computer to be displayed simultaneously on the computer screen and on a large overhead television screen. If you have a computer, but you do not have projection capability to a large-screen (television or otherwise) in your classroom, you should think about getting one.

- Secure the computer equipment against theft. Most insurance companies will not insure equipment such as computers and peripherals unless they are secured in some way that makes them difficult to steal. The Apple Macintosh, for example, has a security slot on the back for attaching cables so that the computer can be padlocked to the table. A company called Computer Security Products, Inc. has an anti-theft device called a Steel Lok Cable System which is easy to install because it requires no modification of the equipment, such as drilling holes. The system consists of heavy-duty steel plates, cables, and padlocks. A steel plate is bonded to the surface of each piece of equipment to be secured. The cable connects the equipment together
through the eyes on each of the steel plates and the padlock is used to secure the set of connected equipment to the table or cart on which it sits.

- Electronic devices should be plugged into a surge suppressor to protect the components against "spikes" in the power supply. Otherwise the chips in the computer(s) might get "fried!" This is especially important if you live in a part of the country which is more vulnerable to blackouts or brownouts. Be sure to locate the surge suppressor in a place where the power switch cannot be accidentally turned off. The worst place to put it in a classroom is on the floor! Usually a surge protector strip comes with recessed hanger holes which allow it to be hung from screws located in some out of the way spot (on the underside of a table, at the back of a desk, or on the wall).

- Display rules of correct classroom computer use close to where the computer is located, and occasionally go over the rules in order to foster responsible computer use.

- Students with disabilities will want to use the computer, too. In the interests of equity you may need to acquire special devices for data input and display for special needs students. Voice recognition, touch screen overlays, braille keyboards and screens, scanners, and speech synthesizers are examples of the many adaptive devices that are available today. Students in wheelchairs should have adjustable or recessed tables which allow them to get close enough to work comfortably (figure 4.5).

Fig. 4.5 Workstation that is easily adjusted for accessibility

- Keep food and drink away from the machinery. We discussed this in chapter 2 in the context of taking care of disks and disk drives.

- Each computer in a school must have antiviral software installed on the hard drive. An example of such software is Symantec Corporation's Norton Antivirus virus
Chapter 4: Educational Computing Environments

A computer pod or cluster Your classroom may contain several computers. At least one of the computers should be set up independently and on a mobile cart so that the teacher can use it for group presentation purposes. The setup for the other computers will vary from room to room depending on the age group, and on the size and shape of the room itself. Do not hide computers behind carrels. Visibility and open setup encourages collaborative use, which often results in the best outcomes.

Selfe (1992) notes that computer labs, especially those with "sound-proofed study carrels" arranged in rows, make it difficult for students to collaborate on tasks and share information. Instead, Selfe recommends, among other things, that computers be arranged rather in clusters or pods to facilitate collaborative/cooperative learning—the discussion and sharing of work and ideas. This recommendation would apply as well to the individual classroom as to a lab setting (figure 4.6).

Fig. 4.6 Oakville, Ontario’s, library cluster or pod of computers

The planning, design, and management of the computer lab or multi-computer classroom (one-to-one computing)

All the safety and ergonomics-related recommendations spelled out above for computers in the classroom should be applied as far as possible in the computer lab or in the classroom where every student has a laptop computer.
Chapter 4: Educational Computing Environments

The layout of the classroom will vary depending on the size and configuration of the room. Any layout should be carefully thought through to make the most of the conditions. It will be worthwhile to begin by briefly reviewing the steps in this planning process.

The classic approach to problem-solving devised by Polya (1945) applies equally well to planning the layout for a computer lab. Let us say that you have been given the task of designing the layout for a new computer lab. Here are the steps you should take to help guarantee that your design will be the best possible, given the circumstances and constraints under which you will have to work.

**Step 1: Understand the problem**

Plan ahead, and start planning as early as possible.

Consider the physical setup of the room. How many electrical wall outlets are there? Where are they located? Will you need more? What kind of lighting is there? Will it need to be changed? What is the minimum recommended distance between machines (Apple recommends 3 feet). How many computers can reasonably be accommodated in the room?

Consider the hardware and software that will be used. How many computers will need to be accommodated? What type of computers will the lab house? Will the computers be stand-alone, or networked? Will they need to be networked to some other local site (in the school building) or remote site? Will there be one printer per machine, or will the computers be hooked up to one or two high-speed printers?

Consider the expected users of the lab and their needs. Who will use the lab? What furniture will need to be acquired (tables, chairs, cabinets, shelves)? Will the lab be used as a classroom? If so, what extra equipment should be available? What ergonomic features should be considered to enhance the users' comfort and productivity?

Consider security. What type of antitheft devices will be needed? How will they be installed? What other security measures will be necessary (lab supervision, shut down procedures, lock up, and so on)?

Consider protection against power fluctuations or outages. Is the school located in an area of the country where such fluctuations or outages justify an Uninterruptible Power Supply (UPS)? If so, what kind of UPS will serve your needs: standby or online?

Produce a report (some call it a proposal) specifying the requirements for the lab, including a statement of the objectives for the lab, with answers to questions such as those raised above.

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2 An online UPS routes the AC power supply from the wall outlet *through* a DC power supply (battery) to the machine. In so doing the battery is constantly charged, which means that it will always be fully charged when the AC power supply fails. A standby UPS routes the AC power supply from the wall outlet directly to the machine, bypassing the battery. Each time a power failure occurs the battery power is drawn down—and not automatically re-charged, which means that the UPS will eventually fail unless the battery is regularly checked and re-charged (Eisner, 1992).
Chapter 4: Educational Computing Environments

Discuss the report with all interested parties: students, teachers, and administrators. Visit labs in other schools. Do not rely on your own resources. You will be surprised what good ideas other people have. Once a lab is set up, its layout becomes chiseled in stone, difficult to change. You want to do your utmost to get it right the first time.

Step 2: Devise a plan

Map out the lab on a scaled down floor plan as recommended earlier. Make sure all the requirements drawn up in Step 1 are taken account of in your design. The purpose of the requirements is to make sure you do not overlook anything. Remember: the further along you discover problems the more difficult they will be to fix.

Step 3: Carry out the plan

This should be fun if you have done a conscientious job in Steps 1 and 2. There will probably still be surprises, but there will be far fewer than if you neglected the planning.

Step 4: Look back

Once the classroom has been set up for one-one-computing and is in use, monitor its use and abuse. Learn from experience with an eye on future installations. Make any modifications as they become necessary. Careful management, constant maintenance with attention to detail, and frequent evaluation will significantly prolong the life of the technology-ready room.

Recommendations for Lab or Multi-Computer Classroom Management

Many of the recommendations for computer use in the classroom apply equally in the computer lab. The following recommendations should also be considered.

- Every lab should have full time technical support. Heavily used computer equipment needs constant maintenance. Students will also need support for hardware and software use. The best people to take care of the latter are trained and supervised student volunteers who acquire valuable social and leadership skills in such roles.
- Do not forget about students with disabilities, a subject we already touched on.
- If you have a choice, connect the computers in the lab to one or two high speed laser printers. This will work out much better than having one printer per machine. It is much easier, for example, to maintain and support one or two quiet, high-speed networked laser printers than 10 or 20 slow and noisy dot matrix printers. It is also less expensive.
- Think about an Uninterruptible Power Supply (UPS). This is no longer too expensive an outlay, and can save much grief, especially in areas of the country where power outages are frequent. It only takes a fraction of a second to lose hours of work. You may need to think about installing this UPS option in the lab. You should still display recommendations for correct computer use as recommended above. (See figure 4.8 above). These should include the all-important recommendation to remind students to back up their work regularly.
Chapter 4: Educational Computing Environments

- Route cables and outlet boxes so that they are concealed and unlikely to be accidentally disturbed. There is already enough danger of loss of power without leaving cables to be tripped over and plugs disconnected.

- Do not allow eating, drinking, or rowdiness in the lab. Children (and adults, too, for that matter) will get away with what they can. Do not just post a notice and expect instant acquiescence. People generally have no problem obeying rules as long as they know what the rules are and that they will be applied consistently and fairly.

- Encourage collaborative learning. Do not use carrels. Have enough extra chairs so that two or three students can work together at a station. Provide comfortable seating.

Figure 4.7 illustrates an increasingly typical layout for a one-to-one computer classroom or lab, where a range of learning technologies are available for the students to use (notice that the students still like to work together—collaboratively).

Fig. 4.7 A multiple computer classroom

It is beyond our scope here to cover in more depth the planning, design, and management of a computer lab or multiple-computer classroom. Fortunately, there are many published sources for this kind of material, and your best resource is often the company that supplies the equipment for the lab. For example, Apple Computer (1991) contains an excellent and thorough review of the factors involved in establishing and maintaining a computer lab. Some of the recommendations in this chapter are drawn from that publication.
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LOOKING BACK

The moral of Aesop’s fable *The Bundle of Sticks* is that unity gives strength. There is more to creating a computerized classroom than simply adding a computer system to the educational mix. Teachers have to be trained, the technology has to be supported, and the environment has to be carefully prepared. The computerized classroom will become an effective learning environment when all facets of its organization—appropriately-trained teachers, well-prepared students, and well-chosen technology tools—are designed to work together to form a unified whole in the service of education.

In this chapter we have examined the technology skills that should be acquired by technology-using teachers (following the ISTE NETS model). We have examined, too, the concepts of teaching and learning that should be assimilated by the teacher who wishes to effectively incorporate the computer into the curriculum. We have also examined important aspects of the physical setup—the ergonomics—of the computerized classroom where learning can take place in a comfortable environment conducive to intellectual pursuits.

Appropriate training and a prepared environment are prerequisites to effective education. With a clear understanding of both, we can now proceed to look at the ways in which computer technology—hardware and software—can be integrated to enhance the process of education.

LOOKING FORWARD

Schools today recognize that they must change. In this chapter we have examined the fundamentals of that change, the training of teachers and the physical and ergonomic infrastructure of computing environments. It is now time to review the many applications of computers in schools.

Chapters 5 through 10 will thus examine the many technologies, both hardware and software, that have been developed for classroom use, along with the methodologies that have developed around computer-integrated teaching and learning. Ideally you will have the opportunity to use a variety of learning systems while you are studying the chapters that follow because the only way to acquire the skills necessary for competent computer use is hands-on.
Chapter 5: Computer Managed Instruction

**Chapter Five**

**Computer-Managed Instruction (CMI)**

We live in a time of such rapid change and growth of knowledge that only he who is in a fundamental sense a scholar—that is, a person who continues to learn and inquire—can hope to keep pace, let alone play the role of guide.

*Nathan M Pusey (1907-2001), past President of Harvard*

It takes a lot of preparation to teach just a little.

*Eleanor L Doan (1918- )*

**LEARNING OUTCOMES**

Much of what a teacher does goes unnoticed. Teachers devote a great deal of time to professional development, immediate and remote preparation, evaluation and follow-up. Good teaching requires all of these activities.

Unfortunately, K-12 teachers can rarely find time for these activities during the school day, let alone immediately before or immediately after each class. There are two reasons for this.

- First, one class is often closely followed by another during the school day, especially in the K-12 environment. Time allocated for planning is often consumed with ad hoc administrative tasks. Before school and after school, time is sometimes allocated for parent conferences and faculty meetings. So most of a K-12 teacher's "immediate" preparation for class has to take place at home, in the evenings and at weekends, during which time the teacher must also be occupied with lesson planning, evaluation and follow-up tasks such as grading and assessment.

- Second, remote, or advance, preparation—reading around one's subject matter, attending conferences and workshops, keeping abreast of ideas and changes in the field of education—often takes place outside the context of the school year. It takes place during the semester on a catch-as-catch-can basis and as time and energy allow. In most U.S. states, teachers have to take academic discipline-related courses to maintain their certifications to teach. Many K-12 teachers attend conferences and take courses during the summer months, school vacations, and on weekends.

So any help teachers can get with preparation, evaluation, and follow-up would be appreciated. This is where the computer can play an important role.

"Good tools," quipped Eleanor Doan, "do not make a good teacher, but a good teacher makes good use of tools." A teacher confident with computer-managed instruction (CMI) uses the
computer in many ways to support and facilitate that broad range of classroom administrative tasks that are such a time-consuming responsibility.

In this chapter we will discuss ways in which computer systems can help teachers and administrators manage their operations in such a way as to save time and increase efficiency. Success, however, depends entirely on the people using the systems that are introduced. Thus, this chapter will also examine ways in which the computer can be used to improve instruction and assist in the general management of the teacher’s job, both inside and outside of the classroom.

Here are the topics that will be covered in Chapter 5:

- Introduction
  - People, Not Computers, Increase Productivity
  - The Computer Is Here to Stay
  - Success with Computers Does Not Come Easily
- Teachers and Productivity Applications
  - The Word Processor
  - The Database
  - The Spreadsheet
  - Drawing and Painting Applications
  - Presentation (Authoring) Applications
  - Web-based Presentations
  - Multimedia Applications
  - Graphical Organizers
  - Communications Software
  - Useful Utilities
- Other Elements of CMI
  - Using Electronic Templates
  - Preparing and Maintaining Curricula and Syllabi
  - Planning Lessons
  - Preparing Learning Materials
  - Assessment
  - The Smart Classroom
  - Distance Learning
  - Managing and Guiding Students
  - Communicating Between Home and School

INTRODUCTION

People, Not Computers, Increase Productivity

A recurring dream is shared by members of administrative bodies in all walks of life. They dream that to increase productivity and improve efficiency all one needs is up-to-date technology. So they buy computers, put them on people's desks, and wait for productivity to somehow magically
improve. As all too many have found out, the objective often remains a dream and sometimes becomes a nightmare.

Although they are getting smarter and faster, computers are only as efficient and productive as the people using them. So their users must be given the time, ongoing training, and support to use the technology effectively. It widely acknowledged in the computer world that the only absolute rule is "Junk in, junk out." It is the quality and quantity of the input that makes the computer a productivity tool. In education, the most important input is the education of the teachers who will be using the tools.

The Computer is Here to Stay

Due in large part to growth initiatives like e-Rate, the support of the business community (through recycling and gifts outright), and over 70 billion dollars in state, federal and local spending, the availability of computer technology in schools has increased greatly since 1994. In the United States, 99% of the public schools have access to the Internet and at least 94% have computers with Internet access in instructional rooms. The ratio of students to instructional computers with Internet access in public schools is, on average, 3.8 to 1 (US DOE 2006). Many states and districts now have 1-1 laptop computer programs for some or all students and all faculty members. The computer is beyond a doubt a permanent part of today's instructional environment.

Success with Computers Does Not Come Easily

Conscientious teachers at all levels of education devote time and energy above and beyond the call of duty in order to be effective in the classroom. This is especially true of teachers K-12. The report of the National Commission On Excellence in Education titled A Nation at Risk (1984) noted this "dedication, against all odds, that keeps teachers serving in schools and colleges, even as the rewards diminish." There is no reason to believe that this has changed; there is every reason to believe that the odds are even more stacked against the teacher. Against all the odds then, many of these teachers have learned to use computers and have successfully incorporated them into their curricula.

One can understand a reluctance to make the effort to master computing skills. However, teachers are learning to use computers in the classroom. By 2000, only 39% of public school teachers with access to computers or the Internet in their classroom or elsewhere indicated they used computers or the Internet "a lot" to create instructional materials, and 34% reported using computers "a lot" for administrative record keeping (NCES, April 24, 2000). It is clear that instructional use of this

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1 e-Rate (the Schools and Libraries Universal Service Support Mechanism) is a federal program that provides eligible schools with discounts on approved telecommunications, Internet access, and internal connections costs. Learn more at the e-Rate website: [http://www.usac.org/sl/](http://www.usac.org/sl/)

2 This number is significantly higher in schools with a high poverty student body, one of the unfortunate characteristics of the "digital divide" in this country.

3 Cynical viewpoints notwithstanding, the great majority of teachers are conscientious and do credit to their profession. All professions have their share of individuals who are not conscientious. The teaching profession is no exception. However, it is in the nature of the teaching, like other care-oriented professions, to attract a higher proportion of caring and conscientious individuals.
technology had to improve, especially in light the rapid growth of student use of all kinds of technologies. The good news is that change has happened. By the year 2005\(^4\) the online survey NetDay Speakup reported that:

> Teachers say that technology is having a positive impact on their teaching and on their students' success: As a result of technology, teachers say their jobs are easier (74%), they communicate more with parents about their children’s progress (47%), their lesson plans and student’s learning experiences are richer because of information from the Internet and multimedia opportunities (47%), and students take a more active role in their learning (47%).

(Project Tomorrow 2006)

Teachers continue to need help. It is estimated that over 30 hours of inservice or professional development training are required for teachers to feel comfortable with technology integration. It is no surprise then that The National Education Technology Plan make improved teacher training as the 3\(^{rd}\) Action Step (US DOE 2006). Practical impediments, such as time and finances, often prevent schools and districts from providing necessary training. The practicing teacher must often rely upon online and peer-supported professional development to improve technology skills. Even so, time for learning and practice is hard for most teachers to find.

Perhaps more teachers would be motivated to embrace computer technology if they could see that it not only improves the effectiveness of their teaching, but that it can also save time and effort. With this in mind, let us examine practical steps that teachers can take to reduce the class management burden, thus allowing them to devote more time and energy to doing what they like to do and do best, which is teach. Along the way, we hope that teachers become excited about using the computer as part of the teaching process itself.

The following sections present some of the computer applications and Internet resources that teachers are already using in schools. The Case Study at the end of the chapter presents some further class management applications made possible by computer-mediated communications (CMC).

**TEACHERS AND PRODUCTIVITY APPLICATIONS**

Productivity applications are computer applications that have become the core set of tools used in administrative environments. These applications include word processing for tasks that involve writing or publication, database management systems for general purpose record keeping, spreadsheets for numerical record keeping, charting, and data analysis, drawing and painting tools for graphic design, presentation tools, graphical organizers, and communications software for establishing and maintaining contact with other people and with online computing systems. Today's integrated applications, or suites, blur the dividing line between tools; word processing can be done inside of a spreadsheet, drawings and paintings can be added to word-processed

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\(^4\) This is over five years ago, but that is the average gap between data collection and analysis. Teachers can get current data by surveying their own school systems. In many districts and states, this is done yearly.
Chapter 5: Computer Managed Instruction

document, presentations can contain charts and drawings, and many applications generate web pages. Moreover, a new application type, which we might call the “all in one” applications, are readily available to teachers who wish to create, disseminate, portfolio and gather in one digital environment. A key learning phrase will always be “Keep It Simple.” Learning to use the basic tools will provide the teacher with a vast library of useful and transferable computer skills and there is not reason for a teacher to tackle the complex when the straight-forward will do.

Each of these tools has myriad applications in the classroom. In the next chapter, we will focus on their application for purposes of instruction. Here we are concerned with their value for class management tasks – teacher tasks.

It is beyond the scope of this book to explain in detail the features of specific productivity tools. If you are using the Microsoft Office tutorials that optionally accompany this text, you will be learning about the tools in the best way possible: hands-on. These tutorials may be found for free download online at the following URLs:

- Essential Microsoft Office 2000: Tutorials for Teachers
  [http://www.pitt.edu/~edindex/Officeindex.html](http://www.pitt.edu/~edindex/Officeindex.html)
- Essential Microsoft Office XP: Tutorials for Teachers
  [http://www.pitt.edu/~edindex/OfficeindexXP.html](http://www.pitt.edu/~edindex/OfficeindexXP.html)
- Essential Microsoft Office 2003: Tutorials for Teachers
- Essential Microsoft Office 2007: Tutorials for Teachers

If you are not using the tutorials, it is assumed that your studies include an opportunity to work with productivity software. You cannot learn to use the computer without actually using it, anymore than you can learn to ride a bike without riding one. Now days, almost every application creator has a tutorial available – integrated into the application, online, or available for free download. Teachers should not be afraid to ask directions!

**The Word Processor**

The word processor is the most efficient writing tool yet invented. While it has all the advantages of a typewriter, what one types using a word processor is literally never chiseled in stone; it is always available for revision. This alone makes for better writing. A word processor can also handle a far wider range of publishing tasks than a traditional typewriter. Examples of these tasks include working with graphics, cutting and pasting between and within documents, pagination, font and style selection, indexing, automatic tabulation, spelling and grammar checking, and so on.

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5 Universal Resource Locator - the plain language "address" of a web page
6 It should be noted that the tutorials can also be used with Macintosh versions of Office.
7 "Voice to text" tools further expand the efficiency of the word processor, as well as meeting the special needs of many students. Teachers need to keep an open eye for "add-ons" to word processing applications.
Chapter 5: Computer Managed Instruction

In the next section of this chapter (Other Elements of CMI) we will examine some specific uses of the word processor for class management. The word processor not only improves the mechanical process of writing by enhancing the appearance of documents, it also improves the quality of one's writing by encouraging re-reading and revision of one's work. In the networked school environment, word-processed documents can be easily co-edited as well.

The Database

Any teacher who has used a computerized card catalog or shopped at Amazon.com has used an electronic database. The electronic database is designed to store data and make that data available to the user in as simple and flexible a manner as possible. Even small databases can store thousands of records. Those records—let us say they are student records—can be sorted in any order, selected (accessed) individually or in groupings determined by the user, displayed as reports on the screen or on paper, or used to personalize form letters or address envelopes.

Most schools now keep student records in a local or web-based computer database, often called a SIS (Student Information System). Some schools have put a computer on every teacher’s desk and have either connected them all to a central computer called a host or server or made a wireless access easy. The server gives controlled access to the database of student records through the use of access codes and passwords so as to protect privileged data. Teachers often have a need to know information about their students, and schools that make this data easily available to teachers are helping the teachers do their job. Similarly, teachers can quickly input data, such as attendance, behavior, assignment and grade information, making it instantly available to the entire school community (which may include parents). The more teachers know about their students, the better they can attend to individual needs.

Technology-using teachers also are using the database to maintain their own records so that they can produce form letters to parents to keep them informed of their children’s progress in class or personalize announcements.

One important use of administrative databases is for curriculum mapping, which has the goal of making the curriculum of an entire school or district accessible and searchable. This will be discussed in more detail when we focus later in this chapter on Preparing Curricula and Syllabi.

The Spreadsheet

A spreadsheet is a tool for handling numerical data of all kinds. It started out in the late 1970’s as a business tool for accounting applications, which remains a major use of spreadsheets by school administration. But it was quickly adopted by number crunchers in all walks of life, including teachers. The typical application of spreadsheets for class management is for recording and weighting scores for assignments, quizzes, and tests, and for calculating averages and grades. Teachers also use spreadsheets to easily log individual student performance on repeated tasks.

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8 It is Federal law that student records must be protected. As technology improves, this protection can become more stringent.
9 In many schools, form letters are being replaced by comments posted to a student’s online record – a record that both parents and students can access securely.
such as reading and vocabulary development and local assessments. Today's spreadsheet software makes the design of eye-catching and informative charts and graphs a snap, and teachers are also using this tool to create visual aids for mathematics, social studies and science lessons. Microsoft's Excel (pictured below) and Apple's Numbers are two applications often found on teacher computers.

The typical spreadsheet has a selection of built-in mathematical functions (also called formulas) and graphing or charting capabilities that greatly simplify the manipulation of the numerical data. Figure 5.2 illustrates a grade sheet with a chart containing some of the gradesheet data.

Notice the boxes (called cells) in which a formula has been set up to carry out a calculation based on a selected set of scores, such as the total score for one student, the grade as a percentage, or the average score for a class. We will learn later in this chapter about other grade book programs and other instructional uses of a spreadsheet.

Fig. 5.2 Spreadsheet made up of student grades

**Drawing and Painting Applications**

Drawing and painting applications are useful for creating visual aids and learning materials that require illustration. Teachers should remember that students will remember what they see much more often – and much better - than they will remember what they hear.
Drawing software is easier to use than painting software because you can more readily edit what you're doing—change the size of shapes, add drawing objects (shapes, text, clip art, and so forth) here and there and then change your mind and take them away. The process is similar to arrange objects to create a collage. Drawing software is like an illustrator's art processor because you can easily go back and change things after you are done. It has value as well for graphic design and desktop publishing, but it can be frustrating to use "from scratch." For this reason, many teachers make use of the colorful templates that are provided with most drawing programs. These generally include certificates, flyers, newsletters, calendars and greeting cards.

The painting software "canvas" is treated as a single unit, like an oil painting or a watercolor painting, rather than as a collection of objects arranged on a drawing board. The parts of each picture layer are woven together as one work of art. You can still create objects such as rectangles or ovals, along with text, but once you put them on the layer, the objects become one with whatever else is on the canvas, replacing anything that is overlapped—just as with an artist’s brush and paints. Most of today’s paint programs, however, create an almost infinite number of layers within one image, giving the artist great flexibility (and this ability to animate!). The pictures you paint are stored on disk dot-by-dot, pixel-by-pixel, and usually take up a lot more space in terms of bits and bytes than a drawing file. But painting software has the advantage that you can be very, very precise. You literally have control over the color and texture of every single dot, or pixel\textsuperscript{10}, on the screen. Illustrations designed for projection or publication are best prepared in a paint program.

Most of the time, teachers will use drawing software, or the drawing tools contained in most word processing and presentation applications, when they want quickly to create visual material to use with their students. But you will want to learn how to use painting software (such as the free paint applications \textit{Tux Paint} or \textit{Pixen}, or the \textit{Paint} program that comes with Microsoft's \textit{Windows} operating system) for those occasions when drawing software does not allow you to get precisely the visual result you’re looking for.

Another powerful use of paint programs is for the transformation and manipulation of digital images such as photographs and downloaded or scanned art. You will learn more about this in Chapter 6.

Today's high resolution monitors, scanners, and printers, and the ubiquity of digital cameras, have encouraged the development of highly sophisticated digital imaging applications such as Adobe's \textit{Illustrator}, \textit{Photoshop} and \textit{Photoshop Elements}, Corel's \textit{Painter} and the open-source application called \textit{GIMP}\textsuperscript{11}. These applications combine drawing and painting tools, enabling skilled artists to produce high-quality graphic art for use in visual displays, publications and web pages. But the

\textsuperscript{10} A pixel is a \textbf{picture element} or dot of color.

\textsuperscript{11} Open-source applications are made freely available to users over the Internet. They will be discussed in a later chapter.
real beauty of these tools is that they enable relatively unsophisticated users to produce artwork that would have seemed daunting if they had had to produce the same work by hand.

It is not necessary for the teacher to know how to use sophisticated tools to work with digital photographs. In the Apple Macintosh environment, machines come with iPhoto, an application that both transforms photographs and facilitates their capture, organization and distribution. Basic photo editing tools are included with Microsoft Office; these are easy to learn, easy to use, and all you need for basic work with images, such as cropping, rotating or balancing pictures (sharpen, add brightness, and so forth) before they can be incorporated into documents of one kind or another. Figure 5.5 is a screen shot of the editing toolbar in Microsoft Office 2003.

![Figure 5.5 Photo editing tools in Word](image)

All versions of the Microsoft Windows operating system for the PC also include applications, such as Picture Manager, for the capture, organization, printing, sharing and archiving of photographs. Further, most digital cameras and scanners ship with basic photo editing software, which in many cases is all the teacher will need. There are even on-line photograph editing tools! Learning to use any one of these applications adds powerful skills to a teacher's toolkit.

**Clip Art**

The computer can transform anyone's artwork. Straight lines, jagged lines, smoothly curved lines, circles, ellipses, shapes of all sorts are a snap to draw, move into position, and fill with a wide range of patterns, pictures, and colors. When you want to include an illustration that might be difficult for a non-artist to create—like a picture of a ship, a map of the world, or a sports figure—you can use a collection of clip art (Fig. 5.6 on the next page).

Clip art is the term used for sets of pre-drawn images saved in digital form, which one can copy into other documents such as newsletters, posters, and assignments. There are many sources of clip art. The most common are: collections that come with productivity applications; purchased CD ROM or DVD collections; and the Internet. Many teachers create their own clip art collections using scanned, drawn or painted images (even student work).

Clip art is the ultimate transportable object, easily imported into most productivity applications, often as easily as dragging-and-dropping or copying-and-pasting. Looked at this way, it is easy to see why clip art is an important asset for the computer-managed classroom. When using clip art, copyright and Fair Use should always be considered! It is best to use images from purchased image collections or software, or from websites like Discovery School (Fig. 5.6 on the next page) that give teachers permission to use the images for education.
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Learning Assets

The concept of "clips" is a powerful one in the computer world. Often called "assets" or "learning objects," these small snips of often-used media are increasingly collected by schools and teachers wishing to streamline the creation of instructional materials. This has resulted in an extension of the concept of clip art. A teacher who learns to "Insert-Clip Art" in Office will find that sounds, animations, photographs and movies are also available in the gallery. Similarly, universities and large schools are using electronic databases to organize "clips" of test questions, instructional videos, visual data, programming and web page code.

On a small level, the teacher who maintains a well-organized folder of instructional assets is creating such a resource for personal use. In the Apple environment, organization is simplified by the Finder’s Movies, Pictures, and Music folders, all of which are accessible from within iLife and iWorks applications. This is indeed an asset in terms of the time it saves!

Charts and graphs

Charts and graphs are also examples of objects that can be created in one application and inserted easily into another. The computer saves time when producing charts, especially ones that are based on numerical data. Spreadsheets such as Apple's Numbers or Microsoft’s Excel or Works, have excellent charting functions built into them. There is even a free website where data can be quickly charted - to create a clip art chart! The user indicates which set of figures is to be charted, then instructs the computer to go ahead and produce either a bar chart, a pie chart, a line chart, or some combination of charts. The process is simple, and the impact as a visual aid in the meeting room or classroom is significant. As the saying goes, “A picture is worth a thousand words,” or numbers in this case.
Fig. 5.7 illustrates some of the chart formats that can be created online from numerical data using Create a Graph (http://nces.ed.gov/nceskids/graphing/).

Teachers, especially elementary school teachers, can combine clip art and drawing tools to create Venn diagrams, pictographs, and other creative visual representations of data more appropriate to the students they teach. Copy-paste makes this easy!

**Integrated Applications**

The drawing tools in Microsoft *Office* are excellent and nicely integrated with the word processor so that graphical material can be added to handouts. Microsoft’s *Office* suite of productivity software has a large library of clip art that is partly installed with the various programs in the suite, but also extends to the web where Microsoft maintains an ever-growing gallery of thousands of examples of clip art for everything under the sun. This means that users of other computer platforms can use Microsoft clipart as well.

Some of the best tools are the simplest ones. Apple's *AppleWorks* was for years the best all around integrated productivity tool, with its text, spreadsheet, table, drawing and painting tools available in all six of the suite's applications. The beauty of *AppleWorks* is its simplicity: it takes up relatively little room in your computer's hard drive, works quickly, and is easy to learn and use. New Macintosh machines ship with the integrated *iLife* and *iWorks* applications, which also have a consistent, easily learned interface.

Teachers need to be very familiar with one or two of these tools for their own work in preparing for class. But also they should be aware of most of these tools, even if they don't use them all of the time. They will then be able to help their students take advantage of computers for schoolwork and help their colleagues as well. Using the best tool for the job is an important computer skill for teachers, one that requires knowledge of a broad range of applications and
resources. Teachers who have this knowledge will be able to guide their students wisely and confidently.

**Presentation (Authoring) Software**

Several programs have vied for market share in the area of presentation software—software which helps you to develop visually engaging slides for computer-based presentations, to create digital movies, interactive activities, or transparencies for overhead projection or projection using a document presenter. When used to create a digital presentation (as opposed to one that will be printed for distribution or projection), these applications combine text, images, sound, animation and even video elements. All programs support hyperlinking, but the best instructional presentations are linear "slide shows," and it is upon this that the teacher should focus. Teachers are successfully using such presentations at parent nights and conferences as well as in the classroom. Teachers who are confident presentation builders are encouraging their students to create them.

Roger Wagner's *HyperStudio* program has been quite popular in schools and is still well regarded, although it is less often used now that labs are being replaced by laptops. Other commonly found applications are Broderbund’s *KidPix* and Apple's *Keynote*. Learning to use any one of these will provide the teacher with a powerful skill set, for the most important tools and features are similar in all applications. But for ease of use and availability, Microsoft's *PowerPoint* program is hard to beat, and it is probably the one that teachers are best advised to learn. Apart from anything else, it is a component of the *Office* suite of software and as such will be already installed on many recently purchased Mac or Windows computer in the schools. So time spent learning to use *PowerPoint* will not be wasted.

Teachers will quickly be able to produce eye-catching and instructive presentations appropriate for all age groups and for all subject areas. As already indicated, tutorials for Microsoft *Office* designed to help teachers learn all components of the *Office* suite of programs, including *PowerPoint*, are available from the author free of charge on-line.

*PowerPoint* provides the hooks on which to hang thoughts and ideas. The visual appeal of the presentation focuses the audience upon content while the slides themselves organize the presenter. *PowerPoint* has, therefore, value as a lecture crutch. There are occasions when lecturing is the way to go, even with younger children--in order to present information of various kinds. A presentation is not, however, a replacement for a lecture, any more than it can replace an essay; it is a visual presentation of the key topics being covered. As a general rule, presentations should follow the 5x5 rule: no more than 5 bullet points per slide, each containing no more than 5 words. The text might be interspersed with well selected pictures, charts or tables, even video, musical or audio clips (most presentation software applications have a voice recording feature) to add humor, emphasis or spark. Occasionally there might be a hyperlink to a relevant page on the Internet or a text box containing a longer piece of important information.

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12 Hyperlinking means moving back and forth between slides in non-linear fashion, much like navigating a website.
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Managing with PowerPoint (or other presentation application)

If the presentation is to be projected, the projection in the room should be powerful enough so one barely has to dim the lights. It is important to have ample ambient light for students to take notes and for the teacher to interact with them during the course of the lecture. Every now and then the teacher might grab a piece of chalk and toss some ad hoc diagram, word, or phrase on the chalkboard. In classrooms equipped with a Smartboard, the teacher is able to capture these spontaneous annotations and notes, saving them as an annotated slide show.

Fig. 5.8 An interactive SmartBoard

It is a good idea always to give students, or audience, a three hole-punched handout (three slides per side of a single sheet of paper) that provides a miniature version of the presentation. They will then have a lined area next to each miniature slide where they can take notes. Producing such handouts is a printing option in most presentation applications. Quite a few students will still choose to use their notebooks, however. The teacher might also post the slide shows to the web so that students who miss a class, or do not take good notes, can check them out. All presentation applications simplify this process.

An alternative for the teacher presenting in a computer lab or a classroom with laptops is to distribute the entire presentation, on CD, flash drive (also called a USB drive or keydrive) or over the network. This allows the viewers to add comments and notes to slides during the presentation, creating a personalized slide show.

Other teachers create only the skeleton of the presentation, filling in the "details" as students generate ideas during discussion or research.

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13 The Smartboard, or electronic whiteboard, is a powerful, but expensive, teaching tool that extends the concept of "chalkboard."
Both students and teachers can benefit from the multimedia extension that PowerPoint provides. It is another powerful example of how the visual presentation of information and ideas enhances learning. In an era in which a typical child is exposed to 8.5 hours of non-school media a day (video games, Internet, music, home computers) and actually uses media 6 to 6.5 hours a day outside of school (Kaiser Family Foundation, 2005), it is often helpful for the teacher to have a multimedia "hook."

Presentation tools also can be used for class management. Here are a few of examples of this. The first idea comes from Nicole Foster in Baton Rouge, Louisiana.

Here is an idea I got from a class I took that uses a PowerPoint as a timing device to help kids keep track of time left to complete an activity. Just make a slide for each minute an activity takes. For instance, a 10 minute activity would have 11 slides, each saying 10 minutes, then 9 minutes and so on down to 0 minutes. Have a “Bells and Whistles” occur when the last (11th) slide comes up, and have the presentation automatically progress every minute. Students can easily see how much time is left to do an activity if it is placed on a big screen, and no one can complain that they didn't know. You can hide screens as well, if you want the presentation to run for a shorter time.

Other class management ideas come from Glenna Norton.

I use PowerPoint in my classroom, but not as a lecture crutch. At the beginning of the year, I post the classroom rules so the students can look them over as they get settled in and I assign seating. I also use it to post steps in a process we are getting ready to do. No matter how many times we review the process, someone will have missed it. It is a time-saver for me so that I don't sound like a broken record. My room has no chalkboards or white boards and it is a simple way of showing the kids a process without repeating yourself, especially if you time each slide and loop it to start over again.

Web-based Presentations

More and more teachers are learning how to create and maintain their own web pages. In the next section we will discuss the communication advantages of this. A web page is also, however, a powerful visual presentation, one to which the student or other intended viewer can return anytime, anywhere (as long as there is an Internet connection).

It is now very easy for teachers to present content on the web - all you need are a way to makes web pages and a place to put them. A free WYSIWYG (What You See Is What You Get) web page composers is built into the Netscape Internet browser. Microsoft Word and AppleWorks documents can be saved in .html format - instant web pages! Even PowerPoint presentations can be exported in .html. The newest Macintosh operating systems support iLife, an integrated, media-rich system that makes web page creation a snap. Teachers with local (in school) web

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14 The technology support staff is one of a teacher’s most powerful allies. Their help is essential for teachers wishing to use the school’s web site or Intranet for web page hosting.

15 html, htm, or HTML, is the "hypertext markup language" that browsers read to display web pages. Although it is useful for teachers to know the basics, in depth knowledge is not longer necessary for the creation of an instructional web page.
space or inexpensive .Mac accounts (available from Apple) can easily and quickly create and upgrade instructional and information web pages.

Many schools are using First Class, a multipurpose e-mail application, to host teacher web pages. Additionally, many organizations and companies provide web space, homepage templates, and even tutorials free to teachers. YourHomwork.com (http://www.yourhomework.com) and HomeworkStation (http://www.waveside.com/homework/) are just two examples. A free, global and secure web space for schools, which includes special communication tools and school networking, is available at Oracles Think.com (http://www.think.com). The communication and instructional uses of web pages will be discussed in later chapters.

A relatively new development is the availability of district-hosted web applications. Moodle is an integrated, open source, solution that allows teachers to create informational and research-guiding web pages, as well as quizzes, chat rooms, forums and more. NoteShare is an inexpensive application for the Macintosh (currently) environment that allows teachers to make any instructional multimedia “notebook” available to students over a web server.

Although there are many free website and web page hosting services, such as MySpace and Geocities, we don't recommend them to teachers. These sites are supported by advertisers and not selective in any way. Visitors to such sites will see banner ads and alluring pop-up windows, and, perhaps more importantly, will have access to all other sites hosted by the provider, many of which contain adult content inappropriate for children. Use of a secure hosting solution, either in-house or education-specific, is highly recommended.

One exception to this is the use of blogs and wikis as core teacher web spaces. Safe, secure and easily managed services are freely available to teachers. Edublogs.org, Class Blogmeister and Wikispace, and pbWiki are highly regarded examples. Teachers will .Mac accounts and Apple computers can manage their own blogs. By electing this solution, teachers can create instructional content and classroom communications “on the fly” - that include relevant documents, images and other media. They can even create and manage student blog spaces! This trend, which borders upon but is safer than “social networking,” is one today’s most exciting productivity solutions.

**Multimedia Applications**

As we have seen, media is everywhere today. The classroom should be no exception. Virtually all of the applications mentioned in this chapter will support sound and video as well as images and words. Teachers today need to have some facility with creating and manipulating these media formats.

Luckily, applications and help are readily available. In the Macintosh world, iMovie and Garageband simplify the job of recording and editing video, sound and integrated documents. Free applications, such as Audacity, facilitate music recording, or “ripping” (recording from a CD), and many teachers use iTunes to download and organize songs and podcasts. As mentioned before, most presentation applications support both animation and sound recording. Most importantly, presentations can be exported (saved as) video files, generally in the QuickTime format. These QT files are compressed, so that the movies can easily be transported or shared.
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We should not ignore the huge growth of online media. *YouTube* is the leading source of short video clips, but both commercial and educational videos are also readily available on the Internet. All that a teacher needs is a “plug in” application that will enable the web browser to capture and save the video file and the appropriate view application (*QuickTime* or *RealPlayer*, for example). The inexpensive *QuickTime Pro* makes it possible to edit or “patch together” short videos, so that the teacher controls the content of the presentation. Each new generation of applications makes the process friendlier. Teachers can always ask their students for help!

Today’s teachers should have an elementary knowledge of how to create and manipulate sound and video files. They must also be mindful of copyright considerations. FairUse applies to presentations created for class use, but does not apply to material that is made available in violation of copyright!

*Graphical Organizers*

Graphical organizers do just what their name implies; they organize information and ideas graphically, or visually. Sometimes called "concept mappers," these tools have endless uses for the teacher. Most teachers have used "bubbles" to brainstorm ideas on the blackboard or added arrows, circles and colors to planning notes. Most commonly, graphical organizer applications are used in planning. They organize the planning process, from brainstorming to presentation or publication.

Organizers indicate not only the chronological progression of a lesson or process, but also the interrelationships of the many elements or steps. They are also often used to create content for instructional presentations or to gather and organize notes from a meeting, both tasks important for the teacher. Moreover, documents prepared using digital organizers can be archived, easily updated, and shared in many ways with administrators, students, parents and peers.

Draw programs can be used to create visualizations composed of shapes and text. Spreadsheets and word processors can be used to create timelines and tables. Programs specifically designed for these purposes, however, are much less frustrating to use and much more efficient.

Probably the most used graphical organizer is *Inspiration*\(^\text{16}\) ([http://www.inspiration.com/](http://www.inspiration.com/)). If used only for brainstorming lesson plans, this is a powerful tool for the teacher. One great advantage is the ability of the teacher to change and annotate a diagram, or web, created by the application (see Fig. 5.9) as part of the evaluation process or as new ideas and information become available.

Another advantage of *Inspiration* is the ability to add web page hyperlinks and appropriate, attractive images to a diagram. Lastly, the compact visual nature of *Inspiration* makes it useful in collaborative planning sessions. Diagrams can be linked and annotated by group members. Diagrams can be saved as web pages and as digital images, enabling the teacher to share them in a variety of ways. A completed diagram can be exported as a fully hyperlinked and indexed website. Further, the diagram can be converted into an outline and exported directly to *Word* or *AppleWorks*, or converted in one click into a *PowerPoint* slide show!

\(^{16}\) *Kidspiration*, the elementary grade version, is less widely known
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This versatile application offers the teacher many classroom management tools and quick, efficient organizational solutions.

![Diagram of classroom management tools](image)

Fig. 5.9 *Inspiration* template used for self-evaluation

Tom Snyder's *Timeliner* ([http://www.tomsnyder.com/products/product.asp?SKU=TIMV50](http://www.tomsnyder.com/products/product.asp?SKU=TIMV50)) is a graphical organizer whose major use is to quickly create timelines. Teachers can use this tool in the planning of lessons and long-term projects, printing banner and poster timelines or sharing them as images files. Like *Inspiration*, then, *Timeliner* is a powerful presentation application. It has a secondary use, however. Because a *Timeliner* "event" can contain media elements (narration, video, music), graphics, and web links, it is a wonderful tool for electronic portfolio building. Portfolios can be displayed digitally by viewing the "events" on the timeline in slideshow mode.

**Communications Software**

The subject of communications involves the use of local and remote (wide) area networks to link people and computers for the purpose of data and information exchange. Today, internet connections are ubiquitous in schools. Further, the e-Rate program (discussed earlier), and state and local initiatives, have greatly increased the number of schools that have in-house networking, either wired or wireless. It is increasingly likely, then, that a teacher will be required to complete many essential classroom management tasks using either an internal network or a web page.

\[\text{Data is the raw material of information, information being the mind-enriching experience once data has been transmitted, processed, understood and assimilated by the human brain.}\]
Communication is the lifeblood of education. The more schools cultivate opportunities for their constituents (administration, teachers, parents, students, community at large) to communicate the better—whether within the context of the school, within the larger community of the school district, or beyond. Such communication is the best means to break down prejudice and barriers between people.

Communication applications are key class-management tools when it comes to establishing and maintaining close contact between parents and the school. Such contact is vital to an educational institution's success. Children who are aware of the collaboration between their parent(s) and the school are much more likely to gain the maximum benefit from the educational experience. We will return to this subject later in this chapter (Communicating Between Home and School) and again in chapters 7 and 8 when we discuss computers & communications (C&C). Briefly, voicemail, e-mail and online systems are replacing "the backpack post office" and its reams of printed announcements. Teachers need to learn the tools and methods that their schools have created to meet communication needs.

Browsers are communications software to manage access to the Internet and the World Wide Web, where teachers from around the globe share experience and teaching materials, locate essential information such as current state standards and School Report Cards, and join bulletin boards and lists to share ideas with their peers. As you will learn later, web-posted assignments and announcements are used by many teachers to keep parents and students informed. As mentioned earlier, many schools are also developing web-based SIS (student information systems) to facilitate the communication of all student data.

E-mail is another essential communication technology, one that most teachers are already familiar with. As schools make e-mail available to teachers, communicating with peers is becoming an important part of the teacher's personal preparation. Listservs and mailing lists link teachers to other teachers with similar needs and interests. Internally, schools now frequently communicate in-house and in-district through e-mail, often eliminating printed announcements and voice messaging entirely. Lastly, as will be discussed later in this chapter and in Chapter 7, e-mail has a niche in home-school communication, perhaps the most important communication of all.

The Internet is probably the fastest growing technology of all time. It is no surprise, then, that new applications and tools are constantly being developed to maximize its use. Several advances have already been embraced by educators around the globe. These include "real time" communication tools, such as IM'g (instant messaging), chat, and videoconferencing, cellular communication tools, such as e-mail, photography and texting, and asynchronous communication occurs through posting messages that others can read at any time.

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18 Because e-mail is the Internet activity most often undertaken by adults, it is reasonable to assume that most teachers have personal e-mail accounts already. However, using a school account for professional communication is more secure and highly recommended.

19 A mailing list is a group of e-mail addresses that will receive the same message with one click of the Send button. A listserv is an automated mailing list, generally comprised of those who have subscribed because they share a similar set of interests or learning goals.

20 *synchronous* is another term for "realtime."

21 *texting* is the term for inputting a message using a phone pad.

22 *asynchronous* communication occurs through posting messages that others can read at any time.
communication tools, such as online bulletin boards, forums, video streaming, blogs, podcasts and wiki's. Free, open source, and online tools for the creation of blogs, wiki's, messaging and podcasts are available online. Increasingly, supporting applications are included with new versions of computer operating systems.

The "tech savvy" teacher should keep abreast of new tools, many of which will be explored more fully in later chapters. As is true with all Internet use in the classroom, however, teachers should be cautious and careful about implementing these new tools and technologies. As is true with all of the tools mentioned in this chapter, the wise teacher will fully explore a new tool before using it with students. Luckily, the education community is aware of this, and information, guides and mentoring are readily available in online communities, through blogs maintained by experienced teacher-users, and in educational publications.

It is important for the teacher to be a confident user of the tools provided by the school and available in the educational community. As you have already learned, it is the nature of technology to change rapidly and for education to lag behind the business and personal worlds in the inclusion of "gadgets" and new tools. This is often for the best, but at times teachers who are not aware of new tools and methods find that this affects their ability to manage effectively in the school environment. Conversely, it is good for teachers to remember that education is about students and teachers - it is about people. Often the best communication application is face-to-face, in "real-space."

**Useful Utilities**

Teachers who have computers on their desks, access to a computer in a lab or office area, or the use of a PDA (Personal Digital Assistant, such as a PocketPC, Palm device or new digital smartphone) can take advantage of several useful time-management utilities. These include calendars, memos and notes, address books and file finders. Once again, this kind of software is only as organized as the people using it.

**Calendars** Teachers need to schedule and keep track of endless important dates: due dates, meeting dates, conference dates, vacation dates, and personal dates. Digital calendars are an alternative to the pocket datebook. They come in many forms. Yahoo and other services provide free calendars to registered users and groups. Education website host services generally provide interactive calendars. Both the Windows and the Apple operating systems contain calendar utilities that can be synchronized with hand-held devices. E-mail applications such as Outlook and FirstClass have a calendar feature.

Both the Palm and the PocketPC operating systems have powerful calendar systems. Some schools have created interactive online calendars that can be used by teachers.

Because on-line calendars and calendar applications come with perpetual calendars, you need only enter the year; the system works out which day of the week January 1, 2009 falls on, and whether or not it is a leap year. On the screen, one can display a day, a week or a full month,

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23 A utility, in computerese, is a small application that packs a wallop, often doing an essential small task inexpensively and better than anything else. For the purposes of this chapter, the more general definition of the word, ("a useful tool") will be used.
like a hard-copy calendar, and enter data into each date. One can add details to an entry by opening up the box for a single day and typing in more extensive notes.

For example, say you have a department meeting scheduled for March 10. You would enter the time of the meeting in the box for March 10, then open up the box to add notes about what you want to bring up at the meeting. Another useful feature of most digital calendars is an alarm that can be set to correspond with a time set on a certain date. For example, you could have the computer or PDA remind you at 3:00 pm that you have a department meeting scheduled for 3:30 pm on March 10. Of course, this will work only if you happen to be using the computer or PDA on March 10!

Most calendar applications also have a utility called the "To-do" list, in which the teacher can note and categorize the specific tasks associated with an event, to be completed by a certain date, or just to be completed, period. Checking off items as "done" is a rewarding element of classroom management. The list and calendar together provide a useful record of a year's work!

Lastly, many calendars can be shared with a group, allowing teachers to enter and retrieve current appointments, meetings, and other scheduling information that is important to classroom management. Other uses of the shared calendar are for collaborative planning, a growing trend in large educational projects, and the scheduling of shared spaces, such as auditoriums and meeting rooms. Many teachers use student-created calendars to organize student projects or to maintain an overview of all student deadlines and tests across the grade curricula. This is a powerful way in which students can take responsibility for their own learning tasks.

**Memos** Another useful utility is a digital note pad for memos. Like calendars, they come in many forms. On a PDA, the memo is a built-in function. Another fun form is the digital sticky, a utility that mounts a stack of virtual sticky notes directly on the computer desktop.

A personal note pad is easy to set up on a teacher's computer, for the modern multitasking operating systems enable you to have several applications and files open at the same time and easily switch from one to the other. One of these files could be a Notepad document, which you would keep permanently available in the taskbar to enable you to enter notes in the form of memos, reminders, ideas, dates, to-do lists, even images and shopping lists! At the end of the day, before shutting down the computer, you would simply run off a copy of the Notepad document, if necessary, or save it for future use.

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24 This is called "concurrent processing" in computerese.
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**Address Books** An address book is a database. Although many teachers keep colorful hand-written address books handy, it is useful to keep school contacts in a different, digital file. Both the Microsoft and the Apple operating systems have address book utilities, linked to the e-mail application. Additionally, e-mail applications like Eudora and FirstClass include an address book utility. Teachers can use these utilities to quickly locate and insert e-mail addresses, to create their own mailing lists, to locate phone and FAX numbers, and to quickly merge names and addresses into form letters and labels.

**Other Utilities**

Desktop computers also come with built-in utilities such as a calculator or graphing calculator, an alarm clock, or a file finder. Similar to the "Find" function in most computer applications today, a file finder is useful if you have dozens of files on disk and you cannot remember where you saved the file you need or, even worse, you cannot remember the name of a file. The utility will help you search all the files on a disk on a trial and error basis, using a subset of the name you think you might have used. Newer find applications also allow you to search the text of a file for a keyword string.

Then there are utilities such as card and label makers. These are useful when you want to give the children inexpensive cards or when you want to create business cards or CD labels. Desktop utilities such as this can often be downloaded\(^\text{25}\) free of charge from the web at sites such as [http://www.download.com/](http://www.download.com/), Tucows.com ([http://www.tucows.com/](http://www.tucows.com/)) or Version Tracker ([http://versiontracker.com/](http://versiontracker.com/)). Just type "card creator" or "label creator" into the search box and try out some of the programs. *AppleWorks* and *Word* also have label-making utilities built into the word processing applications.

One of the best things a teacher can do is to teach students to use these a utilities – and charge them to do so. Students can then create notebook and file labels, or take care of making a birthday database, say, and getting cards ready in time. Alternatively, teachers can locate free "virtual card" and "e-card" makers on the Internet and have students send them to each other. Of course, students and teachers will need individual or classroom e-mail accounts (more about this later in this chapter).

Remember, your job as a teacher is to help children by doing and discovering. You can model this by doing and discovering for yourself!

**OTHER ELEMENTS OF CMI**

**Using Electronic Templates**

If you have been using the tutorials that optionally accompany this text\(^\text{26}\), you will be familiar with the concept of templates, which are also known as stationery documents or forms. To a great

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\(^{25}\) *Downloading* means capturing a digital file housed on one computer (on this case, via a web page link) and moving it to a local computer or storage device.

\(^{26}\) Tutorials for Microsoft Office designed to help teachers learn all components of the Office 2000 suite of programs are available free of charge on-line at [http://www.pitt.edu/~poole/Officeindex2.html](http://www.pitt.edu/~poole/Officeindex2.html)
extent, much of the paperwork that we use both in and out of the classroom is standardized. This is true whether the paperwork is something as simple as a personal letterhead or a permission slip, or something relatively complex such as a disciplinary report or a curriculum map.

Usually, schools develop templates or forms for these purposes, with fill-in-the-blanks spaces for data entry. There are at least three problems with paper (hard copy)-based templates:

- It is necessary to produce multiple copies and store them somewhere where they can be easily accessed in anticipation of need—so they waste paper and take up space. Moreover, teachers can spend a great deal of time separating and organizing multiple carbons.
- Once forms are printed (usually in large quantities!) they cannot be easily changed—so if it is necessary to update the forms, the old ones have to be scrapped (they usually become memo pads if one side is unused).
- Completed forms, whether done by hand or on a typewriter or word processor, must be entirely rewritten when changes are necessary.

Electronic templates, on the other hand, have none of these disadvantages. Once they have been designed and saved they can be shared with the rest of the administration and/or faculty on an as-needed basis. Where faculty members have their own computers, the personal set of templates they might develop for instructional or class management purposes would be saved in an appropriately-named subdirectory or folder on their hard disks and backed up in some way (always a good idea).

Formal templates, such as medical treatment forms used to supply information and permissions should a student be injured or taken ill while at school, would need to be controlled more carefully by a central administration. After all, assuming that all the teachers have their own computers, and assuming that every teacher knows how to use the word processor or other software used to create a template, how would one control changes to such formal templates if they were not centrally located? As soon as they were distributed onto multiple machines, it would be possible (Murphy's Law says it would be more than likely!) that inadvertent changes would creep into them.

The ideal situation, and one embraced increasingly by schools and districts, is for schools to have every faculty or administrative computer networked together. One computer, called a server, is centrally controlled and managed. Everyone with access to the network has different levels of access to different sets of files or data, controlled by passwords or predetermined based upon the user's login name. Certain files, such as student personal records, are available for read-only access by faculty; they can read the data, but they can't change it or add to it. Likewise, copies of certain templates are available only from the central repository on the server. In this way the format and content of these critical templates is less likely to be corrupted by arbitrary change.

The "next step" for schools and districts is to integrate all school-wide forms into an SIS. This web-based system displays records both interactively, so that staff with permission can add and edit data, and statically, so that appropriate members of the school community can access and

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27 It is relatively easy to design a database layout or word processing template that will facilitate this task.
read grade, attendance and other records. Such integrated access is a powerful communication tool.

Other templates, such as letterheads and lesson masters, are stored on each faculty member's machine or in a personal folder on the server, so that they can be customized to serve that faculty member's needs. Many of these templates can be shared among faculty. Indeed, a well-organized school would make some individual—a computer coordinator, perhaps—responsible for setting up a system whereby this sharing was formalized and encouraged.

Many useful templates are included with applications that are often used to generate graphics, publications and web pages, such as Office, AppleWorks and Inspiration. These include calendars, lesson planners, and activity organizers. Additionally, these applications allow the teacher to create her own template for distribution to students or colleagues.

A useful exercise would be for you to get together with a few classmates or colleagues and brainstorm to come up with a list of as many template possibilities as you can think of (consider using a graphical organizer for this task!). Then go through the resulting list to separate critical from non-critical templates. The next step would be to go ahead and create the templates, trying to use the best productivity tool for the task. Save your templates and share them. This will be one of the recommended exercises in the Do Something About It section at the end of the chapter.

Preparing and Maintaining Curricula and Syllabi

A syllabus is part of the content of a curriculum. Zais (1976) reminds us that the word "curriculum" comes from the Latin for "racecourse." Zais goes on to point out that many confuse the curriculum with the program of studies followed by students in their race toward graduation. Other interpretations define curriculum as course content, planned learning experiences, a structured series of intended learning outcomes, a written plan of action, even a "hidden" entity defining the unspoken outcomes of a specific educational experience. The concept of "curriculum" is, in fact, as diverse a concept as "educational goals" because the curriculum is, in the end, whatever an educational institution sets out to promote in its students. The curriculum can be painted with broad brush strokes describing overall goals of the institution; it can be painted with fine brush strokes describing the detailed specification of learning experiences and methodologies that are used in practice to achieve the goals of the institution; or it can be painted with any degree of precision in between.

Moreover, there are larger considerations, of which the teacher must increasingly be aware. Some courses, such as AP (Advanced Placement) courses, have suggested or predefined curricula. All states now have a detailed set of Learning Outcomes, or Learning Standards, which are correlated to the curricula and assessments of the individual schools. Many national academic organizations, such as the NCTM (National Council of Teachers of Mathematics, http://www.nctm.org/standards/) have created subject standards and contributed these to National Standards. Lastly, NCLB requires states to apply its standards, through testing, to reading,

28 Locate standards at the Education World website: http://www.educationworld.com/standards/ You will also find material here on NCLB.
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mathematics and science curricula and to be publicly accountable for student performance. Any one or all of these standards and guides may need to be correlated to a teacher's curricula.

Much of the planning a teacher does is on a much smaller scale. If we think of curriculum at the subject level, we can talk of the math curriculum, the language arts curriculum, the social studies curriculum, and so on. Each curriculum is promoted by a series of courses, and each course is described by a syllabus detailing its content and learning outcomes.

A curriculum is not static; nor is a syllabus—though a syllabus will change more frequently than a curriculum. This is because a syllabus tends to reflect the current realities of a discipline even though its primary objective is to promote the long-range goals of the curriculum. For example, the syllabus for a geography course in the social studies curriculum will naturally be subject to frequent change in order to reflect current thinking in the field and, if it is contemporary geography, current world affairs. If it does not, then there is a problem with the administration of the course: the course content will become progressively out of date. Although this is not true of all courses (for example, courses that offer instruction in the unchanging fundamentals of a subject such as mathematics), it is true of most.

Now, as the classical Latin scholar Publilius Syrus observed in his Moral Sayings: "It is a bad plan that can't be changed." Curricula and syllabi that are drawn up and saved in digital (soft copy) form will be more likely to remain current than those that are produced only on paper (hard
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copy). This is because it is easier to change a digital file. When doing advance preparation for a new school year or a new course, a teacher who only has a hard copy version of a syllabus will be less inclined to update it because it may mean rewriting the whole thing. The teacher with the digital version knows that the syllabus can be quickly updated to reflect new topics, methodologies, and so forth. Moreover, it can easily be shared with colleagues!

Curriculum Mapping

Many schools and school districts have undertaken a process called "curriculum mapping." Developed by educator Heidi Hayes Jacobs, curriculum mapping uses a school-wide or district-wide database to collect curricular data across all grades and academic areas, aligning it to the school calendar. Data is collected in three areas: content (essential questions, key concepts), skills, and assessments. It often includes syllabi and lesson plans and correlations to standards. It should come as no surprise that curriculum mapping is almost always digital, completed either over a network or on a website. Teachers benefit greatly from both the mapping process and the mapping product. As a tool for curriculum development and planning, especially interdisciplinary planning and vertical articulation (following an academic area across several grade levels), a completed map is a powerful tool. Those curious about curriculum mapping might take a look at the work of Oregon Episcopal School. Their map, completed with Rubicon Atlas, an online mapping application, has been made partially available to the public at http://oes.rubiconatlas.org/login/options.asp?UserID=0.

Planning Lessons

Another classical philosopher, Seneca, had this to say about plans: "Our plans miscarry when they have no aim. When a man does not know what harbor he is making for, no wind is the right wind." Lesson plans are drawn up as part of the immediate preparation for a class. Most school districts require that teachers not only prepare written plans for every lesson, but expect the plans to be available for inspection, too. Aside from the obvious practical necessity of having something laid down for a substitute teacher to follow, lesson plans are crucial to the process of achieving educational goals.

Lesson plans are more prone to change than syllabi or curricula. It is difficult to predict much ahead of time what will be covered on any particular day. Lesson plans from previous offerings of a course are useful, of course, but they may need to be rearranged, moved forward, moved back, updated with regard to content, and so on. Fortunately, more and more school districts are accepting lesson plans that have been prepared on the computer instead of using preprinted lesson-plan books or lessons prepared by a textbook publisher. This is another application of the templates we discussed in the previous section. It is easy to prepare a template is that based on the model used in a school district's lesson-plan book. This template can then be made available to any teacher who wants to use the computer for planning. The plans, once prepared, can be printed out and collected into a ring binder for inspection, deposited in a folder on an administrative server, or added to a digital document that can be viewed by all teachers (often, all three occur).

Advantages to using the computer for lesson plans include:
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• The plans are easy to read because they are not handwritten. In fact, teachers can project plans on a screen or whiteboard instead of writing daily plans or class outlines on the chalkboard.

• The plans are more likely to be detailed since it is quicker and less tiring to type in data than to write by hand.

• Plans that have been used before can be easily modified if necessary and reused. Moreover, they can be easily duplicated and filed for use in multiple formats and ways.

• Computerized lesson plans are more flexible. They can be easily rearranged, re-sequenced, added to, or deleted. This is true both for short term and long-term planning. Some schools insist on teachers using bound lesson plan booklets, which clearly limits flexible lesson planning. In addition, a bound booklet does not allow for idiosyncrasy with regard to different approaches to class preparation.

• Plans that have proved highly successful with students can be shared with other teachers through online databases, such as the Educator's Reference Desk (http://www.eduref.org/Virtual/Lessons/) — a database containing thousands of lesson plans and teaching ideas submitted by teachers from all over the world. The best schools foster collaboration between the teachers at various age levels. Coordinating the collection and sharing of electronic learning materials is a good way to give added value to such collaboration.

Teachers in search of lesson plans and lesson plan templates will find the Internet a fruitful resource. A "Google search" (http://www.google.com) for "whale lesson plans" (for example) will result in literally thousands of "hits." To help the busy teacher, there are many portal sites that collect lesson plans (often reviewed) and index them by content and subject. In addition to the Educator's Reference Desk, PBS TeacherSource (http://www.pbs.org/teachersource/) and Bernie Poole's EdIndex (http://www.pitt.edu/~edindex/) are reliable and current resources. Increasingly, educational organizations, museums, magazines, journals and newspapers are creating digital lesson plans to supplement their exhibits and stories, and universities are sharing lessons created by inservice teachers, providing a goldmine of sound materials. The wise teacher will locate the most useful sources and return to them regularly.

Preparing Learning Materials

Copy masters, illustrations involving graphics in general or graphs and charts in particular, seating plans, style sheets, word lists, puzzles, questionnaires, quizzes and tests, assignment specifications, summary sheets, handouts of all kinds: these are the bread and butter of the teaching profession. Not only is a picture worth a thousand words, but directions are more likely to be followed if they are written down, and concepts are more likely to be digested if time is allowed for them to be mulled over.

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30 This database complements and overlaps with ERIC (The Educational Resources Information Center), established in 1966 and newly available at http://www.eric.ed.gov.
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It stands to reason that the computer is the best tool to use to prepare this kind of material. Even illustrations that might take extra effort using a computer, as compared with preparing them freehand on paper or on the chalkboard, will benefit in the long run from being captured as a file on the computer because of the increased flexibility afforded by this approach. If some detail of a design needs to be changed, this can be accomplished easily on the computer, whereas a non-computerized freehand drawing might need to be completely redone.

As discussed earlier in this chapter, in the digital world individually created instructional elements, "assets," or "learning objects," can be endlessly recombined, reused, and shared. Every piece of digital learning material is potentially a piece of a presentation, lesson, or assessment.

About Boards

Digitally created and distributed lesson materials do not mean that the chalkboard will no longer be a useful tool in the classroom. On the contrary, it is difficult to think of a more valuable medium for the spontaneous visualization of ideas. Often, on the spur of the moment, teachers create remarkably effective diagrams in response to ad hoc interactions with an individual or a class. Too often these remarkably effective diagrams are dutifully erased, either to remove clutter from the board, or to clear the board for another teacher scheduled to use the same room.

One solution to this dilemma is to acquire an electronic board (a Smartboard, Mimio-Board, etc.) for each classroom so that such material can be saved and catalogued for future use. But this solution is still expensive for schools. More realistically, teachers should jot down a copy of any visual material that has been created on the fly on the chalkboard so that they can later transfer it to electronic form. Better yet, and thinking digitally, teachers can assign a student to take a digital picture of the board at the end of class. In the course of a single year, dozens of such digital assets might be created, updated, and perhaps shared with colleagues.

Desktop Publishing

Today, everyone's work can look good. As we have seen, the latest versions of word processors such as Pages and Microsoft Word incorporate more and more features that originally characterized desktop publishing (DP) software such as Aldus PageMaker and Microsoft Publisher. Teachers who use these modern word processors can easily create columns of text and tables, add frames and images, and create complex layout designs, along with the usual page layout features expected of word processors. Also, today it is easy to use different fonts (character styles) in a wide range of font sizes. Each of the above applications provides templates to help streamline the process. Producing professional-looking documents for distribution to students, parents, or colleagues is well within everyone's capabilities. Everyone's work looks good.

Extending Your Productivity Toolkit with the Web

The Internet is becoming an invaluable resource for the busy teacher. Producing "just the right" presentation, worksheet, puzzle, or assessment used to mean blackline masters, file folders of

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31 Actually, chalkboards, blackboards and greenboards, are being gradually replaced by "whiteboards" due to the negative effects of chalk dust on both human beings and computers and the positive effect of a white background on projection.
samples, or expensive software containing "teacher tools." It is now possible to locate online "masters" that will enable you to quickly generate attractive and personalized instructional materials. Sites such as abcteach (http://www.abcteach.com/) and Discovery School (http://school.discovery.com/teachingtools/teachingtools.html) facilitate the creation of puzzles, activities and worksheets by providing interactive online templates. Many sites are collecting work created by other teachers or publishers. One of the largest of these is Quia (http://www.quia.com/web/), where teachers and students may access interactive quizzes and activities (such as matching games and hangman) or, for a small fee, create them. StudyWiz (http://studywizspark.com) is a commercial online course-management application used in many 1-1 laptop programs for activity creation and document distribution. Some, like Scholastic Online Activity Center (http://teacher.scholastic.com/activities/), are portals for activities in many topics and grade levels. Other sites, such as FunBrain - English (http://www.funbrain.com/) and The National Library of Virtual Manipulatives for Interactive Mathematics (http://matti.usu.edu/nlvm/nav/vlibrary.html) provide interactive activities for specific skills or content.

Internet instructional resources are enormous. A Google search for "mammals word search" will, for example, provide you with a list of over 100,000 links to online word searches about mammals. Locating the best resources can be time consuming, but is one of the most worthwhile uses of the Internet for education. Remember the Rule of 3: STOP when you find 3 good resources! Experienced teachers return to the same resources repeatedly, adding new ones when updating is necessary (or, as often happens, the website disappears!)

A good teaching strategies for those with classroom computers is to create a web page or Favorites folder containing links to puzzle, assessment and activity sites where students can create classroom quizzes and activities or take advantage of activities available online. Free online bookmark collectors are especially useful. Portaportal (http://portaportal.com) is one example. It is a wise teacher who takes the time to make such a listing, for this provides control over quality and content, and discourages "free surfing" during class time.

**Assessment**

Assessment is integral to the learning process. It includes teacher assessment of each student, of groups of students engaged in collaborative work, and of the class as a whole. It includes student assessments of each other, and of the teacher, too.

Assessment is both informal and formal. Informal assessment is frequent (several times a day or class period) and takes one of two forms: self-questioning about one's immediate and longer range personal and academic accomplishments and objectives (along with activities in pursuit of those objectives); and questioning about the progress being made by others. In business it is called taking stock. Good teachers create an environment where students are encouraged to be conscientious about conducting this kind of informal assessment, thus taking much of the weight off formal tests and other standardized measures of progress or achievement. Important outcomes
of informal assessment are an affirmation of what is working well and a redirection to a better effort, a different outcome, or a different solution.

Computerized tools that support informal assessment have the advantage of making redirection a reality. Viewing every digital lesson plan and activity guide or rubric (to be discussed next) as a tool for informal assessment encourages the teacher to review and update frequently and "on the fly." Not surprisingly, this is a task that students can take on as well. There are many tools available to support digital journaling. At the simplest level, students (and teachers) can keep an ongoing file in a word processing program. Applications designed for journaling range from the Macintosh specific NoteShare and Journaler to web-based blogging. No matter what tool is adapted by the teacher, it must be used consistently in order to be effective for self-assessment. The added benefit of digital journaling, of course, is that the "journalists" are developing their computer skills.

Formal assessment occurs in many forms, all of which can be digitally managed.

**Portfolios**

Good teachers assess their students on the basis of portfolios of work gathered over time, rather than relying predominantly on snapshots of progress captured periodically. Portfolios are especially important in assessing the objective value of a student's work, regardless of what other students may be doing. No two students are equally capable or gifted. These portfolios are often physical folders containing hard copies of student work. They can also, however, be digital. Digital “documents” (files, images, movies, etc.) are gathered into portfolios that allow the teacher to assess not how smart the children are, but rather, more appropriately, how they are smart!

Data folders, accessible to both student and teacher over the network, can facilitate the collection of portfolio elements. Some teachers use websites\(^\text{34}\), presentation software, like PowerPoint or iMovie, or journal applications like NoteShare to organize and access student work. Others allow students to collect and present their own portfolios, learning how to scan documents and use a portfolio application in the process. How a portfolio is created will depend upon the time and technologies available to the teacher.

Advantages to digital portfolios are many. They are fluid, allowing for rearrangement and grouping of various elements to follow student progress in a specific area or over a specific period of time. At the same time, they are permanent and can be archived year-to-year. Some schools present graduating students with a DVD or CD along with a diploma. Perhaps most importantly, they are real evidence of a student's work, making them invaluable during parent conferences. Some ambitious teachers (who have the tools available) will accompany a portfolio with a short video of the student actually doing the work.

**Rubrics**

A rubric is a chart or checklist that rates student, or group, learning and achievement based upon a scale of clearly defined tasks and skills. It is a powerful tool for assessing multimedia,
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collaborative and authentic learning tasks. A rubric is a template (the same rubric should be applied across the class), so it stands to reason that it is best created on a computer! Numerous examples of good rubrics exist on the Internet\(^\text{35}\), where a teacher can also find RubiStar (http://rubistar.4teachers.org/index.php) and the Rubric Machine (http://landmark-project.com/rubric_builder/index.php), tools for both locating and creating rubrics, and NCREL’s Scoring Guide (http://goal.ncrel.org/spsg/GetProd.asp), a tool for creating checklist type rubrics. Rubrics can also be created quickly and easily by using the Tables function in a word processing program. A simple rubric, created in Word, is shown in Fig. 5.10. One very effective way of organizing rubrics for a classroom is to create them in an application like NoteShare that can hold literally hundred of rubrics on virtual “pages.” These can be printed or digitally distributed to students.

There are some basic teaching practices that will make rubric assessment more rewarding for the teacher and for the student:

- First, a rubric is only useful if students understand it. Having them participate in creating it ensures that there will not be an expectation gap or language confusion.
- Second, create the rubric after the lesson is fully planned and after its goals and objectives have been finalized. Ideally, the teacher should also DO the project before beginning a rubric.
- Third, review the rubric with the students at the very beginning of a project and again halfway through it, making changes as necessary and reminding the students about their goals. Some teachers create several rubrics that assess a large project in “chunks” or activity steps.
- Fourth, use the rubric! Be sure to complete it and review it with the students. Many teachers use rubrics for peer assessment, but this requires close supervision and a great deal of trust within the classroom. Teachers can effectively complete a digital, or printed, rubric as students are presenting their learning.
- Fifth, share rubric assessments with parents!
- Sixth, return to the rubric template at the end of the project. This is the best time to make necessary improvements.

\(^{35}\) One of the best listings is by Kathy Schrock - http://school.discovery.com/schrockguide/assess.html.
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**Fig. 5.10 Sample Rubric for a Survey Assignment**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Table</td>
<td>Contains less than 5 rows, table does not contain headings or contains blank rows or cells. Data entry does not follow directions. Data does not match some items and alignment are not consistent. Chart is not chart or chart is fragment of a format.</td>
<td>Contains at least 10 rows, contains headings and all blank items are consistent. Data is entered correctly. Inconsistent items and alignment. Chart has different formatting than table. Data is entered correctly.</td>
<td>Contains more than 10 rows, formatted appropriately. Table is consistent. Data is entered correctly. Inconsistent items and alignment. Chart has different formatting than table. Data is entered correctly.</td>
<td>Format is correct. Uses font size and margin correctly. Consistent column are the table. Table provides explanation and analysis. Chart has been formatted. Table has consistent formatting, but it is difficult to read.</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Worked poorly or not at all with group members.</td>
<td>Worked well with group members but contributed very little. Other members relied on group too much.</td>
<td>A group member who did a fair amount of the work and kept the task on track.</td>
<td>A group leader who both instructed and directed. Organized group well, focusing on own task.</td>
</tr>
</tbody>
</table>

**Tests**

Are formal tests necessary? It is beyond the scope of this book to dwell on the arguments for and against formal testing. Some would argue that tests (objective, standardized, or otherwise) are necessary because it is naive to expect that all students (and all teachers, for that matter) will conscientiously conduct useful self-assessment. Others argue that fundamental change is needed in the way schools are organized and managed if formal assessment techniques such as tests are to be done away with.

Some schools of thought would do away with formal testing altogether. But for the time being, formal tests are necessary for two reasons:

- Those who pay for the education system need some commonly agreed upon guideline, or benchmark, for assessing the effectiveness of schools, which usually takes the form of scores on tests. The NCLB Act requires that states design and submit assessment results each year, resulting in state-wide tests aligned to learning standards.

- There is a tradition of formal testing in schools, a tradition with an inertia of its own. Where this is the case, formal testing actually dictates to some extent the academic ethos of the school, in regards both to teaching styles and student study habits. Many teachers rely on testing as an important component of their methodology.

Moreover, formal tests that are given to all students over a period of years provide useful, and often important, information about student progress in the skills and content knowledge targeted by the tests. When used *formatively*, or to inform teachers, students and parents of specifically what the student knows and understands along the timeline of a unit or year, formal testing can be an important component of an individual student's educational plan.
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*Using the computer to generate tests*

The computer can help with the generation of tests in at least three ways:

- **Many textbooks come packaged with computerized test generation tools.** The software gives the teacher the ability to create new tests, revise old tests, and save multiple versions of tests with questions ordered differently to discourage cheating in classrooms where the children sit closely together. The package usually includes a database of test questions prepared by the author of the textbook. A good test bank is made up of different types of questions: short essay, multiple choice, true/false, fill in the blanks, and matching, for example. Recently published texts may have websites to support or replace "hard copy" support materials.

- **Using the word processor, teachers can set up test templates, including all the formatting and page layout features.** These templates can be made available for other teachers to use and archived digitally for reuse and revision. Devising and entering the questions would be the only time consuming activity. An alternative to using the word processor is a test generation application such as ExamView ([http://www.fscreations.com/examview.php](http://www.fscreations.com/examview.php)) or free online test and quiz generators such as QuizStar ([http://quizstar.4teachers.org/](http://quizstar.4teachers.org/)) and EasyTestMaker ([http://www.easytestmaker.com/](http://www.easytestmaker.com/)). These packages are not keyed to any particular text. The modules help a teacher create a question file (including graphics, if desired), then create a test, organize the test, and print it out. Once again, the only time-consuming activity is devising and entering the questions. Teachers can also find many utilities online to help with test generation, including special fonts, equation editors that create mathematical problems or expressions with little effort, chart makers, graphing calculators and foreign language fonts and keyboards. It is wise to work with the tech support staff to learn these well before beginning to make a test.

- **There are many reasons for a teacher to involve the students in building tests.** In the spirit of encouraging the students to assess each other and themselves, a teacher can set up the word processor, or a digital NoteShare notebook, for students to submit their own questions for tests. For example, if there are 25 students, each would be given the assignment of designing four or five questions, say, and handing them in by a certain date to a student assigned to enter them into a preformatted word processor file. On the due date, the file would be checked over by the teacher. Errors would be removed and, if necessary, more questions added so as to make sure all aspects of the material to be tested have been covered. A copy of all the questions would be run off and duplicated, or distributed electronically, so that each student would have a study sheet as a guide in preparation for the test. Finally, the teacher would select questions for the test, cut and paste them into a document, run off the test, and give it on the designated date. As was suggested earlier, students can access some of the free quiz generator sites as well, working in groups to create "pretests" for the class. One teacher had students create quiz slideshows in PowerPoint and combined them into one large presentation for semester review. Others use the computer to make testing and pre-

36 One of the best is Equation Editor.

37 Also included with full installations of Microsoft Office, but you need to know how to set them up and use them
testing fun. For example, Jeopardy, Concentration and Who Wants To Be a Millionaire game templates for PowerPoint are available online (search for "PowerPoint games"). These can be projected for full-class review, made available on classroom computers, or posted on the teacher website for students to play at home.

**Grading Tests**

Optical Mark Recognition (OMR)\(^{38}\) is a well-established scanning technology that comes in handy in schools for many forms-based tasks such as attendance, data gathering, questionnaire analysis, test scoring and assessment, checklists, and so forth. The computer recognizes marks made on the printed page and is programmed to interpret them according to a predetermined set of criteria.

Tests that consist of one-option answers (multiple choice, true/false, matching) can be scored in a few seconds, depending on the size of the class. Typically, an optical scanner can process from 50 to more than 150 sheets per minute.

The forms can be purchased from the company that supplies the mark reader, such as Apperson (http://www.appersonedu.com/default.asp).

Online testing is becoming more prevalent as more districts and testing centers learn to develop this web-based solution. The GRE and TOEFL tests, for example, are already given in CBT (Computer Based Testing) centers worldwide. It is also becoming more common for districts and states to use commercial and non-profit testing ventures, such as NWEA (http://www.nwea.org), for student assessment testing. These digital tests, taken only on the computer, are scored immediately. Detailed breakdowns, or *item analyses*, of test questions are generally available over the Internet within a day.

Due to cost factors, volume, and complexity, however, the above methods currently have more application at the national, state and school-district administrative levels than in the individual classroom. However, online applications such as *Quia* and *StudyWiz* allow the teacher to create reusable digital testing experiences for students that also provide immediate digital scoring.

A related technology is the interactive student response system. In classrooms equipped with this system, students with handheld devices respond to projected or paper test questions by using a "clicker" that resembles a remote control. Using this system, teachers can get immediate feedback on student understanding of key content and concepts. Because complete systems come with tracking and logging software, they can also be used for summative assessments at the end of a unit or term. Some systems come with tests as well. Like the NWEA testing described above, these systems are expensive, but provide multiple opportunities for guiding individualized, targeted, instruction.

**Distance Learning**

Although the phenomenon of Distance, or Online Learning will be discussed more fully in a later chapter, this is a good time to alert teachers to this growing trend in education. It is possible now for a student to take a for-credit course entirely online – even to complete high school without setting foot in a classroom!

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\(^{38}\) You might think of it as "filling in the bubbles."
Chapter 5: Computer Managed Instruction

This means that there are teachers who are doing all of the CMI tasks discussed here with only computer tools and without the expectation of seeing students face-to-face. It would stand to reason that there are web-based tools to simplify and support all aspects of the teacher’s job (Blackboard.com is one of large commercial services). However, the course is only as good as the materials that the teacher gathers and creates. A good distance education teacher makes use of the same multimedia and text tools to create digital materials – those that will give students the best possible content delivered in the best possible way – that have been discussed in this chapter.

The best possible way for a teacher to learn about distance education is to take a course. Most state universities now have course available. PBS Teacherline (http://www.pbs.org/teacherline/) offers inexpensive professional development courses, many of which highlight technology. It may even be possible for a teacher to work with the tech support personnel to create an online course that supplements or replaces a class taught! Moodle (http://moodle.org/) is an open source application that makes this possible.

The best online class takes place in a virtual “smart classroom” – one where multimedia in fully integrated into each lesson. This works to keep students alert and interested. The same is true for the traditional, or face-to-face, classroom.

The Smart Classroom

Computers have significantly increased the number of options available to teachers for using audio-visual aids to increase the impact of their lessons. Technology such as tape recorders, film and slide projectors, overhead projectors and videocassette recorders (VCRs) are still part of the armory of audio-visual equipment at most schools. But computers and related equipment, powerful enough and at the same time cheap enough to eventually replace most of these machines, are now proliferating in schools.

Computer-coordinated Classrooms

In the classroom, the computer can be used with other technologies to form a multimedia instructional system, creating what is often called a "Smart Classroom." Such systems facilitate the incorporation of multimedia material39 into lesson plans. In Chapter 9 we will look more closely at the subject of multimedia. CD-ROM discs, interactive videodiscs40 and DVD's packed with computer-accessible media, such as still pictures, video and audio clips, many with multilingual sound tracks, are at the heart of multimedia classroom.

Again it should come as no surprise to the teacher that the Internet is a rich source of free multimedia. National Geographic (http://www.nationalgeographic.com/), PBS (http://www.pbs.org/teachersource/), and the Library of Congress (http://memory.loc.gov/) are among a growing number of institutions that have developed magnificent multimedia content for education. Live radio, webcasts (streaming video broadcasts), podcasts (recorded audio), and short video clips can be accessed through the Internet, often posted by individual educators41.

39 The term "A-V" or audio-visual is being replaced by "multimedia." Many schools still have an "AV Department."

40 The videodisc is a media format that is disappearing. Many schools, however, have large videodisc collections.

41 Because of this, teachers should always preview media before using it in class!
United Streaming's (http://streaming.discoveryeducation.com/index.cfm) video-on-demand service makes short instructional video clips available for a reasonable fee, greatly reducing the need to purchase extensive video libraries. Many state and local museums and libraries are adding similar resources to their websites. Many make it possible for the teacher to create a free "portfolio" of multimedia learning "objects" that students can access directly. The wise teacher will explore the online media resources for each unit, well ahead of time.

Teachers who have Smart Classrooms find that they make much more use of them than they did of traditional audio-visual equipment. This is because, as we will see in Chapter 9, these systems greatly simplify the incorporation of multimedia into lesson plans. Multi-media applications and high speed Internet connections enable the teacher to access interactive media aids during the course of a presentation to reinforce and add to interest to what is being studied. Such materials are available in all subject areas and for all age levels. A history lesson, for example, gains focus from the display of maps, contemporary fashions, architecture, artifacts, speeches, interactive timelines, and so on. History teachers have always appreciated the need to use audio-visual materials such as these. The difference a computer makes is largely logistical: it streamlines the integration of a variety of media by reducing them to a single digital format. This reduces the clutter and handling otherwise involved with paper, slides, transparencies, film, records, audio and video tapes, and other traditional media. In place of a cart of resources, a teacher can now insert a "burned" DVD into a projected computer or access a page of web links.

More important, Smart Classrooms lend themselves naturally to student-directed use for the development of research-related projects and portfolios of all kinds and for all age groups. The Smart Classroom contains hardware and software to make media, technology that was not available in the age of vinyl records and filmstrips. Scanners, for example, can be used to digitize and archive illustrations. Once in electronic form, these can be sequenced and displayed on large screen monitors or projected directly onto a screen, Smartboard or whiteboard using an LCD projector. Add microphones, digital voice recorders and digital cameras (still and video) and a classroom becomes a media production center. Software designed for student use and low-cost media storage devices have greatly simplified the creation of media products. It is the computer that coordinates the production and the presentation; but a smart and organized teacher is the production guide! This is another new role requiring new learning.

A useful exercise for teachers would be to discuss the myriad ways in which a Smart Classroom can be used to enhance learning. This will be another of the exercises in the Do Something About It section at the end of this chapter.

It doesn't take much imagination to foresee a future where digital technologies will transform the way teachers teach and students learn. Chapter 9 will give you the opportunity to learn more about the exciting possibilities.

Managing and guiding students

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42 Sophisticated Smart Classrooms have a computer console than controls many media devices. These may be available in one room in a school, but are not widespread.
Keeping track of students is another time-consuming task. Keeping grades, taking attendance, checking on irregular attendance, following up with communication with the home, keeping notes on each child's attitudes, behavior, health, and home background—these are just a few of the responsibilities that teachers are supposed to take in their stride along with their other responsibilities. Of course, teachers can not do all this as thoroughly as they would like. After all, they also have to teach!

So it would help if there were software to manage tasks such as these; and indeed there is. For example, *Easy Grade Pro* by Orbis Software ([http://www.orbissoft.com/](http://www.orbissoft.com/)) allows a teacher to create an electronic grade book that, like a paper grade book, can store student data (which can be downloaded from an administration database), along with assignment, score, and attendance data on all classes and subjects. It also facilitates report writing by providing forms into which grades and student names are automatically entered. Teachers with PDA devices can use a mobile feature, allowing for assessment "on the fly."

_Easy Grade Pro_ is also available in a “web edition.” This enables a school to use a web server to make the student grade reports available on the Internet, securely of course. Many school are implementing this new generation of digital record-keeping. One huge advantage of web-based grade reports are that they do not have to be printed because parents can also access reports online.

**Guiding Students**

Applications such as _Easy Grade Pro_ can come in handy when the teacher is in the role of guidance counselor because “Knowledge is power,” and relevant, up-to-date information can only improve a counselor’s understanding of a student’s situation. We discussed assessment earlier when reviewing the subject of testing. Another aspect of assessment relates to less easily measured skills, such as social skills, study skills, and creative skills—skills that are more generally related to character and personality. A person's character might be defined as the set of basic traits that make up that person's nature, and personality describes the way that character is projected and perceived by others.

One of the greatest difficulties facing teachers today, perhaps more than ever, is the need to help children who are not "ready" for school. Problems at home, in particular, and pressures in the social milieu as well, can mean that a student may be physically present in class but mentally unable to participate to the best of his or her abilities. Even children from relatively stable family and social backgrounds will bring to the learning process ways of being that demand special consideration. Every child is different and deserving of individual attention.

Teachers are most effective with the children whom they come to know well. Some understanding of a student's character and personality and a familiarity with a student's home background and academic history are important in terms of providing the best learning experience. An experienced and empathetic teacher may be skilled at recognizing character and personality traits by

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43 _PowerSchool_ is a very popular tool for student record management, which goes far beyond grade forms.
interaction with a student. But the only way to learn about the same student's home background and academic history is to ask.

The computer can provide ways for teachers to "ask" without intruding. Journals, bulletin boards and blogs, for example, allow students to express their thoughts, feelings and fears quietly and in a form they understand - a digital form. Some teachers encourage students to create multimedia projects, like web pages and Digital Storytelling presentations, so they can share and analyze their fears and frustrations. The development of an electronic portfolio is often an affirming process for students who are having difficulties.

Similarly, the computer can provide ways for a teacher to guide without intruding. We have seen how teacher created websites can facilitate lesson presentation. Teachers can also create websites containing links to material that will help students with personal and learning issues. Sound tutorials, homework help sites, health information and just plain "growing up" information can be found on the Internet and accessed privately by students. The librarian is a powerful ally for the teacher in the location and selection of these materials. The students themselves are an even more powerful ally.

For more objective data, schools that have computerized databases of student records are more likely to keep teachers apprised of important student data. This is simply because it is easier to do so. Manual collections of data stored in filing cabinets are cumbersome to get at and time-consuming to search through. Teachers are human; the more difficult it is to accomplish a task, the less likely it is that the effort will be made. Because it is important to know one's students well, data about students should be readily available to those who need it. The data can be protected in various ways to ensure that only those entitled to view a particular student's information may do so. Use of such systems, sometimes called "data driven decision making," has been given a boost by the passage of NCLB. One widely-used system is PowerSchool (http://www.powerschool.com/), a web-based SIS (Student Information System) that facilitates almost all teacher and administrative management tasks.

WhippleHill (http://www.whipplehill.com/products/) provides an alternate solution, more appropriate for smaller and private schools. Both companies scale and adjust their products to meet the requirements of the school or school district.

Another useful exercise for teachers would be to brainstorm the contents of the perfect system to both guide and manage students. What data should it contain? To whom should this data be accessible? This will be another of the exercises in the Do Something About It section at the end of this chapter.

**Communicating between home and school**

An important part of any teacher's job at the K-12 level is to hold conferences with parents, either at school or in the home. This interaction is vital to the quality of the educational process, notwithstanding the fact that it is often neglected. When the responsibility for interacting with parents is taken on by teachers, it must either be scheduled during lunch hours, in the evenings, or

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45 Digital Storytelling combines narration, still images and video to present a "snapshot" of personal story.
on weekends, both because of the teacher's heavy class schedule and because parents are not usually available during the day.

In some schools, interaction between the school and the home is coordinated by counselors—or "domestic mediators" as they are sometimes called. This arrangement works especially well when teachers are involved in developing those precious links to the students' homes. The domestic mediator, apart from having the benefit of training and experience, can bring objectivity to the three-way relationship between the parent, the child, and the teacher. Objectivity is especially important whenever, as is often the case, the reason prompting the interaction is some shortfall in the child's performance—for example, poor attendance, unruly behavior, or substandard academic performance.

In several areas, computer technology can foster this extra dimension to education by bringing the home into the school and the school into the home. The telephone system combined with computer technology has given schools the capability of maintaining communication 24/7. Most schools now have a voice mail system. Parents can dial in to a school office or a teacher's voice mail and listen to a pre-recorded message, such as school hours, trip news, or daily assignments. Parents can leave messages of their own, to be responded to later. Teacher access to telephones during the day is often limited, however, and responding to parent requests and information must often be an after-school task - not at all helpful in an emergency!

It is possible for schools to quickly and inexpensively contact groups of parents with a voice message by accessing a central database of phone numbers and "sending" the message automatically. The advantages of voice data are clear: almost every home has at least one phone or cell phone, parents can be contacted during the day at work, and a message can be recorded in many languages. The disadvantages are less obvious: it may not be the parent who receives the message, archiving is difficult, and the communication is one-way; parents still need to initiate contact with the school in order to respond.

More and more common now is the use of e-mail and web-based communication systems. Most schools can, and do, expect most parents to be able to communicate through an Internet medium, either e-mail or web-based. The implementation of such communication systems is not complete, but it is definitely in the cards for teachers to be managing most classroom communications digitally. It is possible right now to teachers to create "free and easy" websites containing assignments, announcements and resources using the school's e-mail or web servers. Fee-based services, such as SchoolCenter (http://www.schoolcenter.com/) can provide a simple and secure school-based solution for districts that do not elect to maintain web servers.

Since these technologies come under the umbrella of C&C, we will discuss them in detail in Chapters 7 and 8. You should recognize for now that the classroom is an extension of the home. Some of the good things about the pre-computer age, such as frequent classroom visits by parents and a personal, supportive relationship between teacher and parent, are being reevaluated and redefined. NCLB has made parent-school communication a national priority. There is no doubt that the need for a home-school partnership is real and ongoing, but the best role of the computer in this partnership has yet to be defined.

46 24 hours a day, 7 days a week
LOOKING BACK

K-12 teachers make money the old-fashioned way; they earn it! Learning to use computers effectively in the classroom takes a good deal of effort and, for those who are understandably frightened by the technology, it takes a good measure of determination as well. Those who have become skilled in using computers as a tool for teaching and learning will attest to the fact that CMI can be an effective ally to the teacher in the task of preparing and managing an environment in which children will feel encouraged to open up to knowledge. This chapter has identified various features of CMI, showing how technology can add a new dimension to a teacher's work with students.

Unfortunately, the computer does not make the job of teaching any easier. Ironically, the computer is such a versatile and enabling tool that computer-using teachers find themselves doing more work than ever, preparing better learning materials than ever, and following up on their students more closely than ever before—all of which take time.

Computers make teaching more effective when quality applications are used to conscientiously prepare and manage the learning environment. When teachers are given the opportunity to learn the new methodologies associated with computer use, and when they are given the ongoing support that must accompany the hardware and software tools, they have shown themselves capable of transforming the way they teach and the way their students learn. The end result is more effective teaching and more time for interaction with students, which brings its own reward.

As Henry Adams reminds us: "Teachers affect eternity; no one can tell where their influence stops."

LOOKING FORWARD

Computer-assisted instruction (CAI) is a growing field with enormous potential. Learning systems that are available today are laying the groundwork for future, more standardized and comprehensive learning environments. We are learning what works and what does not, evaluation of CAI being an important task of all teachers who use it in their classes.

In the next chapter, we will look at the broad range of CAI available today. We will look at different types of CAI, and at specific applications designed for specific subject areas. We also will examine different software and web page evaluation instruments. Finally we will look into the crystal ball and try to predict future directions for CAI. It is an exciting prospect.

Charles Babbage, who, in 1812, invented the Difference Engine which earned him the title of "Father of Computers," Alan Turing, who, in 1936, posited the theory of the computer as a "Universal Machine," and John Vincent Atanasoff, who, in 1939, invented the electronic digital computer—along with the countless other individuals who made small and large contributions to the development of this amazing machine—deserve the gratitude of society in general and of children in particular. Haltingly, step by step, the state of the art in educational computing is
advancing. It is up to teachers to help maintain the momentum, for "all that is human must retrograde if it does not advance."\textsuperscript{47}

\textsuperscript{47} Edward Gibbon. \textit{The History of the Decline and Fall of the Roman Empire}, 1776.
Chapter Six

Computer-Assisted Instruction (CAI)

It is the supreme art of the teacher to awaken joy in creative expression and knowledge.

Albert Einstein (1879-1955)

If a student flunks once, he is out; but an inventor is almost always failing—he tries and fails maybe a thousand times. ... Our biggest job is to teach how to fail intelligently... to keep on trying, and failing, and trying.

Charles Franklin Kettering (1876-1958)

LEARNING OUTCOMES

The term Computer-Assisted Instruction (CAI) describes digital systems that are designed to assist in the learning process, specifically those that can be tailored to the needs of the individual student. When originally defined, CAI described systems comprised of discrete hardware and software, tailored to different teaching methodologies and focused upon a curriculum core (reading, language arts, math). Current use of this term embraces a range of instructional solutions, from courseware applications to district-wide, web-based integrated learning systems.

In general, educational use of technology has migrated from "technology tutoring" to the concept of "technology tools," as discussed in chapter 5. However, as also discussed in chapter 5, NCLB has reinforced the need for standards-based education, resulting in a general re-thinking of the role of CAI in schools1. In this chapter we will examine the various types of CAI with a view to broadening your awareness of what is available in the way of computer-based tools to support education and your understanding about how to use them effectively.

It is beyond the scope of this book to profile in more than cursory fashion specific CAI applications. We are concerned here with concepts, rather than keystrokes. The ideal accompaniment to the study of the material in this chapter, and in the book as a whole, would be hands-on review of as wide a range as possible of CAI applications and tools.

Courseware—software designed to promote specific learning goals—such as age-specific reading, writing, mathematics, science, social studies, music and arts skills—is abundant and available at a price2. Increasingly, courseware is being developed by individuals and

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1 Private schools may not be guided by NCLB. This decision depends upon funding needs and school philosophy.
2 Educational pricing, group purchasing plans and state-supported purchasing plans mean that schools pay much less for computer software than does the public. So it should always be purchased through the school. This is also a wise move in terms of appropriate use licensing.
smaller development teams and made available as freeware or low cost shareware³. Increasingly, teacher-created materials are available over the Internet. Teachers are planning lessons around these tools. We will explore some specific uses of sample tools, for finding the best tool for the task is an important part of the planning process (and a lesson that students will learn by doing!). Teachers are also learning to implement the standards-based CAI that are often available school or district-wide. There are advantages to both computer integration solutions and it is the teacher's role to guide students in their use on a day-to-day basis. General strategies for the successful integration of technology will be explored in Chapter 14. Teachers are also using a third category of CAI, perhaps the one that will be first to the finish line in upcoming years—web-based learning content. We will touch upon it here and cover it in some depth in chapter 9.

This chapter also will examine the process of courseware and software evaluation since, although there are many examples of well-designed courseware, teachers should still evaluate learning materials prior to incorporating them into lessons plans. They must also evaluate the effectiveness of those materials while students are using them, and again after their use in order to determine whether or not they should be used again. This evaluation should be shared with other teachers. Computer technology can help with this task in various ways.

The following topics will therefore be dealt with in this chapter.

- Children want to learn
- Technology Tools: Students and productivity software
  - Productivity Software is a Platform for CAI
  - Word Processing
  - Database Tools
  - Spreadsheets and Charting tools
  - Drawing and Painting—Graphics Tools
  - Authoring or Presentation Software
  - Graphical Organizers
  - Communications
- Technology Teachers, Tutors & Testers: Classifications of CAI
  - Caveat: The teacher should come bundled with the software
  - Software for Drill-and-practice
  - Software for Tutorials
  - Software for Simulations and Gaming
  - Software for Critical Thinking
  - Software for Supporting Learning
  - Computer-based Laboratories (CBLs)
  - Programming and Problem-solving
  - Integrated Learning Systems
- Software evaluation

³ Freeware is distributed freely, but often with little support. Shareware requests a registration be paid to the developer. Both are generally distributed on the Internet.
Chapter 6: Computer-Assisted Instruction (CAI)

- The design of effective software evaluation instruments
- The process of CAI system evaluation and purchase
- The Future

INTRODUCTION

The French writer and educator Anatole France once wrote: "Let our teaching be full of ideas. Hitherto it has been stuffed only with facts... The whole art of teaching is only the art of awakening the natural curiosity of young minds for the purpose of satisfying it afterwards." Learning is more likely to take place if natural curiosity is awakened. As any teacher knows, children to some degree at least can be coerced into the kind of academic achievement that is measured by scores on standardized tests. But knowledge acquired out of inherent interest in the subject matter is much more likely to persist and be retained than that acquired purely for the purpose of passing tests. Inherent interest in the subject matter of a discipline also provides a surer foundation for life-long learning.

Children Want To Learn

A Nation at Risk (The National Commission on Excellence in Education, 1984) recognized "the natural abilities of the young that cry out to be developed and the undiminished concern of parents for the well-being of their children." The report's recommendations "are based on the belief that everyone can learn, that everyone is born with an urge to learn which can be nurtured, that solid high school education is within the reach of virtually all, and that life-long learning will equip people with the skills required for new careers and for citizenship."

The teacher's task is to nurture the student's innate "urge to learn." In this chapter we will look at the various ways in which computer assisted instruction (CAI) can be one tool, but by no means the only tool, for accomplishing this objective.

TECHNOLOGY TOOLS: STUDENTS AND PRODUCTIVITY SOFTWARE

Ralph Waldo Emerson observed: "The person who can make the hard things easy is the educator." Before we examine categories of CAI, we will take a look at how the same productivity tools discussed in chapter 5 can be used by students. The term productivity is used to describe these applications, which are the workhorses of any organization, because workers can get more done in less time when the computer is used to assist them. The same applies to students, who undertake every day the essential job of learning. There is no reason why these applications should not also be the workhorses for the students in a computerized classroom. Creating the opportunities and presenting the possibilities is the teacher's role. At the end of this chapter, teachers should understand this axiom: a minimum of software used well is more powerful than a maximum of software used poorly.
Chapter 6: Computer-Assisted Instruction (CAI)

*Productivity Software Is a Platform For CAI*

Productivity software provides study tools for all aspects of learning. Chapter 1 showed how learning in the language arts, math, science and social studies can be enhanced by incorporating computers into the curriculum. All areas of study require the acquisition of data, or information, in response to curiosity and inquiry. Productivity software empowers the student to *make something* of this information.

The computer has become one of the most important tools to support research, regardless of the academic discipline or level. Students, guided by good teachers, use databases, spreadsheets and graphical organizers to capture, manipulate, and organize data. They use word processors to write about the data. They use graphics tools to design materials to accompany their written and/or spoken descriptions of what they have learned. They use presentation or authoring software to produce multimedia presentations to share their learning.

This process of capturing, manipulating, organizing, and presenting is a profound learning experience, especially when facilitated by a teacher who knows how to stimulate inquiry, who understands when to leave students alone to discover knowledge by themselves, and who is ready to step in with ideas and guidance of an enriching nature that will redirect and reinvigorate flagging research or inquiry.

Educator Jamie McKenzie (1999) writes often about the power of Questioning in the research process. A good exercise for the teacher is the examination of his research cycle model ([http://questioning.org/Q6/research.html](http://questioning.org/Q6/research.html)), with an eye toward understanding how and where productivity software can support the cycle. Gathering, synthesizing, sifting and sorting, revising, and publication are all facilitated by the right productivity tools. This applies to the kindergartner examining letters or bugs, to the AP chemistry student examining recumbent DNA, and to everything in between. When combined with the use of technology to present, access or communicate information, productivity tools become powerful tools for learning.

It is beyond our scope here to dwell more than superficially on the technical aspects of productivity software. Readers should note, however, the sets of tutorials which optionally accompany this text. These tutorials introduce the user to the essential features of the Microsoft Office software, using examples that are appropriate for the classroom.

These tutorials are available for free download online at the following URLs:

- Essential Microsoft Office 2000: Tutorials for Teachers
  [http://www.pitt.edu/~edindex/Officeindex.html](http://www.pitt.edu/~edindex/Officeindex.html)

- Essential Microsoft Office XP: Tutorials for Teachers
  [http://www.pitt.edu/~edindex/OfficeindexXP.html](http://www.pitt.edu/~edindex/OfficeindexXP.html)

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4 Tutorials for Office X for the Mac are available from Microsoft at the following URL:
[http://www.microsoft.com/Education/MacOfficeTutorial.mspx](http://www.microsoft.com/Education/MacOfficeTutorial.mspx)
Let us briefly examine, from the students’ point of view, the features of each of the components of productivity software.

**Word Processing**

In an information age, an individual's ability to communicate effectively both orally and in writing is a key ingredient of success, even of economic survival. An important goal of education, therefore, is to help students develop good communication skills. Teachers are role models, whether they like it or not. Their students look to them for example and direction. So, teachers as well as students should constantly work on improving their speaking and writing skills.

A good place to start might be to take more advantage of the word processor, which is the most used of all computer applications. Chapter 1 made the case for the word processor as a tool for learning. It is already revolutionizing the teaching of writing in computer-integrated elementary and secondary classrooms. A recent study in Maine, which has a 1-1 laptop program for grades 7 and 8, concludes that the more students use their laptops for writing, the better their writing scores are (Silvernail 2007).

Children prefer writing at a computer because of the ease of text modification and revision, and because of the improved appearance of the final product. The net result of this is that the children are motivated to write more, and this alone leads to improved writing skills, especially when they are working with teachers who provide a "prepared environment" where spontaneous intellectual growth can flourish. Not only are the children more likely to become better writers using a word processor; they also are more likely to blossom in all areas of academic life.

Myers (1984) makes a powerful case for Writing to Learn Across the Curriculum. "Writing to learn," he writes, "is based on a growing body of research into the writing process that suggests that writing can be a powerful strategy for learning content. The student who participates in a writing to learn program is likely to learn more content, understand it better, and retain it longer. As a bonus, writing skills are also likely to improve through use." Myers goes on to say: "Writing should be an integral part of any instructional program. It is unfortunate that, outside the English classroom, most teachers provide only limited writing opportunities for their students, usually in the form of note-taking or an occasional essay question on an exam. Writing can do much more. Properly used, it can become the single most powerful tool a teacher can employ." (Emphasis added)

There are many teachers who routinely expect their students to use the word processor for writing, no matter what the academic discipline involved. They routinely work with their students to revise word processed writing assignments until they are of an acceptable
Chapter 6: Computer-Assisted Instruction (CAI)

standard. Such revision is a natural, almost inevitable, component of writing when assignments are word processed. Unlike hand- or type-written work, when the word processor is used revision is much more likely to occur before the assignment is handed in. In fact, Microsoft Word facilitates comment and revision by making a powerful set of editing tools available to the teacher and student (see Fig. 6.1).

Fig. 6.1 Editing tools put to use in Word XP

Many teachers are encouraging peer editing and collaboration on the computer, as early as grade 5. Because the basic word processing tools for formatting and layout are consistent across platforms and software applications, students develop strong skills as they move through the k-12 experience.

Did you know…
The word processor is the best tool for collecting notes for online research. URL’s can be dragged directly into Word, Pages or a note-taking application, where they will become hyperlinks! Even better, images can also be inserted by drag-and-drop!

If we use computers for no other purpose than to actively promote writing across the curriculum, we will have already taken a huge step towards improving the overall quality of children's educational experience. If we also have the students using those word processing skills to communicate over local and wide area computer networks, as discussed in chapters 7 through 9, we can foster the kind of collaborative writing in, and between, students and subject area experts in more and more schools.

Keyboarding remains a conundrum. In general, research indicates that students write more and better if they can keyboard faster than they can write by hand. It is not the role of the classroom teacher, however, to teach keyboarding. Many solutions are available: computer labs often undertake structured keyboarding lessons using proven software such as Type to Learn and Mavis Beacon Teaches Typing. Some schools enlist the help of parents to oversee keyboarding practice at home. Other schools have invested in inexpensive, portable keyboarding/word processing tools, such as the Neo and the Dana

5 Although Word and Pages are accessible to early elementary school students, application such as Davidson's KidWorks, Crick's Clicker, and Kidspiration have features that make them good alternatives.
Chapter 6: Computer-Assisted Instruction (CAI)

Whatever the keyboarding solution, every school that encourages or expects word processing should have a CAI solution, and the teachers should be aware of it.

Database Management

A database program is designed to help the user create files containing up to hundreds or thousands of records, capture the data, store it, rearrange it, sort it on specific fields, select subsets of records and of fields within records, and produce reports. Although modern databases are designed to carry out mathematical operations on numbers, this is not their primary function for student use. For the most part the database is best at handling plain text, numbers and words, dates, and, increasingly, images and multimedia objects.

Fig. 6.2 illustrates a typical database data entry form for the Microsoft Office Access database management system.

The database component of productivity software is relatively easy to use once you have mastered the concept of database management. This means practice. It also means learning to design a database activity that is appropriate to the age group and curriculum. As is the case with software in general, less is often more. Students can be introduced to databases by entering data into teacher-designed forms. Children of all ages can do this, perhaps as
Chapter 6: Computer-Assisted Instruction (CAI)

early as second grade. Even at the kindergarten and first grade levels, the teacher may be able to hand over most of the data entry to the students.6

Teachers should remember that when students access a web Browser, like Google, they are searching a database! But just because students google, they might not google well! Searching well is NOT intuitive – it must be taught. Accurate keyword searching is an essential element of using the Internet for CAI.

In teaching students how to use databases, teachers are also modeling how to make databases. For older students, teachers can design long term team projects in which students research a subject, design a database to capture the data, assemble the data, produce reports using the database package and the word processor, and make a presentation based on their findings. Teachers can locate online projects that extend the data set around the globe—or even design and manage their own!

Did you know…
Most Internet forms now send data to or collect data from a searchable database. As early as kindergarten, students are familiar with these forms and eager to use them. But the COPPA (Children's Online Privacy Protection Act) makes it unlawful for websites to solicit information from children under 13 without parent approval. Teachers must teach children Internet safety rules and guide them toward "kidsafe" search engines, such as KidsClick!
(http://sunsite.berkeley.edu/KidsClick/)

Working with a database can be an important exercise in higher order thinking. For example, databases can require students to classify data by selecting from a checklist of descriptors or categories. Searching a database by dates or keywords can yield "found lists" from which students can create conclusions by compare-contrast, cause-effect, inference, locating patterns or predicting outcomes. Returning to Jamie McKenzie, the database structure invites good criteria for information collection and facilitates the "filter and revise" steps so critical to good research methodology. Asking questions of a database develops another essential skill for the digital age; students using a well-designed tool will learn that information is a powerful thing—almost too easily accessed and manipulated.

A new addition to database productivity tools is the visual mapping of data. Increasingly, data that is input via an online form can be viewed visually rather than in a table or “record.” Not surprisingly, students are fascinated by these tools. Teachers wishing to learn more might peruse a favorite blog for a tag cloud (Fig 6.3 next page) or try out a “next generation” visual search engine such as KartOO (http://www.kartoo.com).

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6 It is a fact of life today that most students have entered information into online databases by age 10.
Spreadsheets and Charting Tools

A spreadsheet, like a database, is a powerful tool for gathering and storing data, manipulating it, and presenting it in various ways. The difference is that a spreadsheet is primarily designed to handle numeric data, whereas a database is best for handling discrete snips of information media. A spreadsheet file consists of a grid of rows and columns. At the intersections of rows and columns are cells into which the data are entered. Fig. 6.4 illustrates a typical spreadsheet exercise using the Microsoft Office Excel spreadsheet software.

This example uses a text object to provide questions; answers could be entered into a second text object. It also displays a bar graph of the data, facilitating comparison of boy-girl totals by providing a visual display. In the classroom, a word-processed survey form could be used to tally footwear data as it is collected.

It would be a good teaching strategy to have all students complete a sample spreadsheet, like this one, and then allow students to work in teams to design and complete a survey of
their own. There are many extensions of an activity begun in this way: writing, math, interviews, research, explorations of how data sets interrelate (for example, if there has been a survey of favorite free time activities, students could ask if more boys like sports because they wear the most sneakers).

The strengths of spreadsheets are their functions and their graphing and charting capabilities. Functions are mathematical formulas (such as total all the values in such and such a column) that direct the spreadsheet to carry out mathematical or logical processing. Such processing, done manually, would be time-consuming and error prone if done by hand, even with the aid of a calculator. Many of the spreadsheet functions are built-in, such as the sum and average functions, used in the spreadsheet shown in Fig. 6.4. But users can also create their own formulas by expressing in mathematical terms the functions they want calculated. Additionally, some of the more difficult concepts, such as mean and median, can be reinforced when data is viewed on a spreadsheet.

All spreadsheets today have a variety of graphing and charting tools. The user can specify a set of values in the spreadsheet—say all the values in a sequence of cells—and press a few keys to tell the spreadsheet to draw a pie chart, bar chart, line chart, or a combination of chart types, including 3-dimensional charts. The chart can then be inserted, as an information clip, into a word-processed document, a presentation or poster, and so forth.

Science classrooms are, increasingly, using data collection and presentation applications, such as Vernier’s Logger Pro, to enrich classroom instruction. These applications, specialized for hands-on research\(^7\), create a real-world environment for students; rather than spending their time to create spreadsheets and enter data, they spend their time analyzing data. The wise teacher keeps this in mind—spreadsheets generally raise more questions than they answer, and a template or graphing tool can focus student attention on important questions and their answers.

As with the word processor and the database, a spreadsheet is relatively easy to use once you have mastered the concept. Once you have learned to use a spreadsheet, teach it to

### Idea Bank: Spreadsheets

| Surveys of anything that can be counted |
| How I will spend $100 |
| A cross-country travel plan |
| Keeping track of homework time |
| Class fund-raising project |
| Ocean depth, mountain height |
| How many of what color? (Skittles, M&M's, Froot Loops, buttons) |
| Plotting numerical progressions and patterns—squaring, cubing, halving, incrementing |
| Environmental studies data |
| Grammar counts—count occurrences of "which" or ";" |
| Probability and prediction |
| Calories and nutrition journal |

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\(^7\) Virtual experiments are also available online and integrated into science applications. These are especially valuable when performing the experiments would involve high-cost equipment or impossible laboratory situations, such as many AP physics or biochemistry lessons.
your students. Software such as Tom Snyder's *Graph Club* provides ready-made lessons for teaching spreadsheets. Sunburst's *Graphers* and Inspiration’s *InspireData* include good lesson plans and support materials. Many lesson plans can be found online and in science, mathematics and social studies texts. The alert teacher will find the best ideas, however, in her own curriculum—gathering, organizing and analyzing numerical data are essential literacy components at every grade level. Students at all grade levels like to count, measure and time. Additionally, data sets to support most k-12 studies are freely available in the library and online.\(^8\)

A spreadsheet is often correlated to a hands-on inquiry activity or a project-based learning activity. Because the medium is digital, students who use the spreadsheet to solve a numerical problem can easily manipulate solution sets and predict outcomes.

We are entering an age of data-driven decision making and problem-solving, one in which workers will need data skills in every workplace. Like the database, spreadsheets challenge students to stretch into higher levels of thinking. The seemingly simple choice of chart style (Fig. 6.5) is a thinking decision—What do I want to display? What does my data really mean?

Students charting pH variation in a guppy tank learn quickly, for example, that a range of 1-10 is meaningless. They then need to ask: What is pH anyway and what do these numbers mean? The same students counting guppies and snails will observe that using a line chart allows them to have 7.5 guppies on a Sunday. Is this an accurate presentation of the data? How could there have been half of a guppy in the tank? The teacher guiding this type of learning is not delivering information; she is exciting curiosity and encouraging thinking.

**Drawing and Painting—Graphics Tools**

Many excellent drawing and painting packages are available for today's powerful computers. Applications such as Adobe's *PhotoShop* and *Illustrator* and Corel's

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\(^8\) Examples would be the US Census Bureau ([http://www.census.gov/](http://www.census.gov/)) and Animal Info for mammal data sets ([http://www.animalinfo.org/spec_ind.htm](http://www.animalinfo.org/spec_ind.htm)).
CorelDRAW™ or Painter can make students who do not think they are artistic feel like birds released from a cage—once they have learned the ins and outs of how to use the software.

Students who are artistic may at first feel inhibited by the constraints imposed by a computing environment. But these same artistic students, because of their special talents, will soon learn to make the software sing. Paraphrasing John Vincent Atanasoff, the inventor of the electronic digital computer, you do not need absolute accuracy to achieve relatively perfect results. In fact, full-featured paint programs play a growing role in a graphic arts and technology programs. CAD (Computer-Assisted Design) software, which enables 3D modeling, time-lapse modeling and virtual walkthroughs, is often found in High School arts and technology classrooms, and a simplified CAD program, SketchUp, is used in middle schools. The school that makes these applications available will find that they also provide wonderful support for astronomy, geology and many mathematics lessons.

Of course, most students will not find advanced tools in the computer lab or on laptops or classroom computers, nor will they need the advanced features of the tools. For the most part, they will be using the more basic tools introduced in Chapter 5. Most educational general purpose and presentation applications contain basic drawing tools, such as those incorporated into the Microsoft Office suite of programs and into HyperStudio. These offer simple drawing and (this is something to look for) charting features. Simplicity suits the learner’s purpose.

Did you know…
There are many file formats in which to save images. The safest are .gif and .jpg. Drawings are best saved in the .gif format and photographs are best saved in the .jpg format. Drawing and paint programs require the teacher or student to pay attention to format when saving. This is an essential skill!

A sophisticated program such as PhotoShop may well get in the way of learning by forcing the student to focus too much on the technicalities of getting a drawing or photograph perfect.
Chapter 6: Computer-Assisted Instruction (CAI)

In any case, all students will come to appreciate a graphic application as a timesaving and creativity-enhancing tool. As is true across the edtech world, finding the best graphics tool for the learning task, and the best task for graphics tool, is the job of the educated teacher.

MacKiev’s Kid Pix™ program is beautifully designed to allow the youngest children to create artwork in an enjoyable, on-screen environment. This is an example of the new breed of educational draw/paint software. Originally an innovative black & white application, the newest generation of Kid Pix includes lively multimedia elements that "grab" students – it even exports animated video to iPods!

Despite its many “bells and whistles,” Kid Pix develops sound skills by introducing young students to basic drawing and painting tools, at the same time making it possible to for the teacher to introduce or reinforce important concepts, such as symmetry, patterns, and story development.

Another excellent tool is GollyGee Software's GollyGee Blocks (http://www.gollygee.com/products/). Designed for education, this application introduces 3D modeling and spatial thinking to elementary students while reinforcing the basic skills needed to use all modern graphics applications. Fig. 6.6 shows a screenshot of a 3D landscape.

The teacher who has the use of a digital camera or scanner is especially lucky. These tools enable students to include digital media in all products, from word-processed documents to presentations. In chapter 5, the uses and value of digital imaging applications such as iPhoto and Photoshop Elements were discussed. These tools are very student-friendly. Classroom projects centered upon student-taken and student-annotated digital images are a powerful learning experience in any academic discipline.

Similarly, images from the Internet enrich student graphic work, often proving key "starter" or "finishing" elements. One caveat: using images from online sources requires students to follow correct citation rules. Insisting upon this sends a powerful message about intellectual property rights. Teachers should include "correct citation of sources" in all assessments.

Fig. 6.6 Two views of a landscape—GollyGee Blocks

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9 Many educationally minded websites, such as the Metropolitan Museum of Art, allow students to use images without permission - but they do require citation!
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Good drawing, painting and special format software enables the teacher to print documents in a range of sizes, from small to very large. Big books can be produced for, even by, the younger age groups. Color maps and other posters also can be printed in large sizes for display on walls in the classroom or around the school. Photoshop Elements and iPhoto make it possible to print contact sheets of various layouts, saving expensive photo paper. Digital imaging tools, then, empower the student (and teacher) by making it possible to present learning "as I see it," archive this, and quickly revise it.

With the addition of new, free online archiving tools, such as Flickr (http://www.flickr.com), classrooms and individual students can also learn to share, document, and safely use digital images. Teachers can create or join Groups to use images for collaborative study. Services like Flickr are also a source of images for media literacy units and newsletters.

**Authoring or Presentation Software**

Presentations pull together all of the elements of student creativity—as their name suggests, they are best used to present the outcomes of planning, research, inquiry, or a decision-making exercise.

Apple’s Keynote is a simple-to-use Presentation application, very similar to Microsoft’s PowerPoint. KidPix and Hyperstudio can also be used for presentations. Slides are designed individually with the help of a template and built-in tools to set the slide background colors and sequencing. Individual slides can contain text, images, animations, sounds, movies, web links. Timing can be automatic or “by clicking.” These are, in a nutshell, the components of any good presentation application.

This is such a powerful school medium, in fact, that many of the most-used school applications, such as Clicker, Kidspiration and Inspiration, have added presentation capabilities to new versions. Others have made it possible to see each “page” as a slide in an automated slide show. Moreover, virtually any presentation can now be exported, or archived, as a Quicktime movie or as a web-ready file. Potentially, the audience for any student presentation is global!

Kids of all ages (including college age students) love using these programs because they are easy to use and fun to interact with. A good teacher will take advantage of the motivational aspects to lure students into learning under the guise of having fun! We will examine these presentation tools more closely in the context of multimedia in chapter 10.
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It goes beyond saying that *making the presentation* is often the most exciting part of a long-term project. Teachers should make sure that the entire project itself is well-structured in terms of attainable and appropriate learning goals and objectives, and that it allows for enough research or inquiry time. Collaboration is a natural fit with presentations, and this too has to be allowed for. Lastly, the digital presentation is generally just one part of the sharing, or presenting, of learning. Few student presentations are self-contained\(^{10}\); most have "real-time" and "real-person" components, often amounting to a mini-lecture. Guiding students in this public speaking exercise is just as important as guiding the digital project.

*Graphical Organizers*

One of the most widely used educational software applications is *Inspiration* (or its elementary school counterpart, *Kidspiration*)\(^ {11} \). These two tools have a powerful mission—they organize student thought. Returning again to Jamie McKenzie's insistence upon the importance of Questioning in the learning process, it is not hard to see that a few good questions will yield a plethora of answers, and it is in this dichotomy that the need for graphical organizers lies.

In its most straightforward use, *Inspiration* collects Answers, Ideas, or Details as they are brainstormed. In fact, it contains a tool, called Rapid Fire, to facilitate this. Ideas or concepts can be associated with images from the included clip art library, from a library created for the project, or from the Internet. Students can add hyperlinks and media objects to projects as they do research.

The true power of the graphical organizer becomes apparent when it is time to organize the ideas. Students are able to manipulate the "bubbles" or concept objects in the diagram by linking them, moving them, coloring them and even annotating them with pop up notes. Ideas can be extended by the insertion of sub-diagrams inside of a single concept. Older students will find that the connected outline, created automatically as concepts are added,

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\(^{10}\) A significant exception to this rule of thumb is presentations created as movies (iMovie, Pinnacle Studio, Flash) or web pages. The process is the same, but, because they are self-contained, they must be much more content rich.

\(^{11}\) There are several other tools that are similar in design. *Cmap*, free tool from the University of Florida, has tools for High School. *PicoMap* is a free graphical organizer for PDA's. *Smart Ideas* is an organizer designed to be used with a SmartBoard. *Freemind* is an open source application.
can also be easily manipulated; many learn that it is at times easier to start with an outline rather than a diagram.

As is true of the best education applications, *Inspiration* and *Kidspiration* come with a wide range of useful templates and strong support from the producers, including web-based tutorials, templates, correlation with standards, and idea books.

In the elementary school, *Kidspiration* (Fig. 6.7) is a powerful tool for developing thinking skills such as grouping, sorting, classification, and sequencing.

**Fig. 6.7 Kidspiration** makes the organization of ideas easy for elementary school students

Visual tools included in the software facilitate the application of these skills to everyday life and to frequently studied contexts, such as school, home, foods and animals. *Kidspiration*, for example, encourages writing with a built-in word processing tool, to which symbols can be added.

Teachers who require students to use a graphical organizer find that students focus upon the topic, theme or exercise and are less easily distracted by peripheral ideas and
nonessential information. When used to support a collaborative or a hands-on experience, the graphical organizer further encourages questioning and probing—in short, *learning*.

**Communications**

You will remember from Chapter 5 that communication, including digital communication, can be *synchronous* or *asynchronous*. Synchronous communication, such as face-to-face speech, signing, online chat, phone conversations, or a videoconference, occurs simultaneously between those involved in the communication. Asynchronous communication, such as regular mail ("snail mail"), e-mail, voice mail, blogging, texting, online forums and bulletin boards, is communication that is received some time after the initial message has been sent.

When a broadband connection\(^\text{12}\) or modem\(^\text{13}\) is used to connect a computer to the Internet, interesting synchronous and asynchronous educational opportunities open up. In this regard, the world of K-12 education is slowly catching up with its big academic brother at the college level and with the rest of the computerized world.

Within the classroom or the school, students can use e-mail, chat and tools shared over the school network\(^\text{14}\) to manage group projects, learning how to collaborate in a controlled environment.

Classes of students can also function as "teams," collaborating and peer-editing through wikis, blogs and bulletin boards that extend the school day into all hours. In a growing number of k-12 schools, both in the United States and elsewhere in the world, students are being offered the opportunity for cross-cultural interaction with students and adults from all over the world. Others connect students in real time to remote experts and learning experiences that enrich and extend the classroom experience. Learning in these schools is taking on a reach that extends beyond the school, out into the local and global community.

Computers and communications (C&C) technology has the potential to extend every student's educational experience. As already noted in Chapter 5, it can bring the home into the school and the school into the home, making possible a synergy which has been shown to have a significant impact on the quality of the educational experience for each individual student (Bauch, 1990). But it can also bring the world into the school and the school into the world in ways that are destined to have a profound effect on how education happens.

In the next chapter we will look more closely at the contribution that C&C can make to our students' educational experience. Meanwhile, a useful exercise would be for you to get together with your colleagues or classmates and discuss other ways in which productivity software can further learning.

\(^{12}\) Broadband, or high speed, connections are becoming more prevalent in schools. These include cable modems, DSL lines, and T1 lines. With students, speed can be everything.

\(^{13}\) A modem is a device that converts the digital data in the computer to analog form so that they can be transmitted over the telephone system.

\(^{14}\) Aquamind’s *NoteShare* is an example of such a tool.
TECHNOLOGY TOOLS AND TESTERS: CLASSIFICATIONS OF CAI

Caveat: The Teacher Should Come Bundled with the Software

Caftori (1994) reminds us that children, unsupervised, do not necessarily achieve the learning objectives for which specific software has been designed. The computer does not, and should not, replace the teacher. Good teachers bring diagnostic and motivational skills to the classroom, along with the knowledge and experience to guide children on their intellectual journey.

There are seven categories of CAI, each of which is appropriate under different instructional circumstances and therefore requires a different pedagogical approach. These seven types of CAI are as follows:

- Drill-and-practice
- Tutorials
- Simulations
- Critical Thinking and Enrichment
- Computer-based Laboratories (CBL)
- Programming
- Integrated Learning Systems (ILS)

The ensuing sections clarify the unique characteristics that have made these applications powerful tools in the classroom.

Software for Drill-and-practice

Drill and practice, which is a learning methodology used to reinforce familiar knowledge, is a type of CAI that, in recent years, has received a certain amount of bad press. The criticism in some cases stems more from disparagement of drill and practice as a CAI genre than from dissatisfaction with the effectiveness of the methodology. In its basic form, drill-and-practice is less exotic than other forms of CAI, such as simulations, games, or virtual reality, for example; and thus, from the point of view of the student, less fun.\(^\text{15}\)

Other criticism comes from a belief that the methodology itself is flawed and basically ineffective as far as higher-level learning. Bigge (1982) points out that, ever since Edward L. Thorndike in the early 1900's debunked mental

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\(^{15}\) A criticism, as we will see, that software producers and website designers have spent a lot of energy responding to.
Chapter 6: Computer-Assisted Instruction (CAI)

discipline as a working hypothesis for learning, there has been a rejection of the idea that the mind can be exercised with a view to strengthening its intellectual capabilities. Drill and practice, Thorndike would say, is not the way to nurture ideas.

Some mental abilities, however, involve skills (remembering a list of items, manipulating numbers mathematically) rather than concepts, and in these cases drill and practice ("mental gymnastics") is clearly an appropriate learning methodology. It can also be argued that drill and practice is, indirectly, as fundamental to the learning of intellectual concepts as it is to the acquisition of mental and physical skills.

With the advent of high stakes testing in all states, drill and practice has taken on a new dimension – and new research studies. In general, these studies find that the individualized nature of the applications increases student interest and learning gains (Kim 2006 and Vernadakis 2005) and that even in non-academic areas, such as social behavior, students can benefit from well-designed CAI. (Miller 2007)

Furthermore, perusal of the Grab Bag titles will show the teacher that all drill and practice applications are now “edutainment” – they are alive with media in all digital forms. Basic is not basic anymore.

**Reinforcing Basic Skills** So, drill and practice is an important learning reinforcement technique for building basic knowledge. It also is critical for honing the myriad, basic intellectual skills (such as number manipulation, vocabulary use, spelling, sentence construction, following the steps in problem solving, and so on) that are the foundation for higher-level intellectual activity, otherwise known as Higher Order Thinking Skills (HOTS). This is not to say that the computer is always the best vehicle for drill and practice. It depends on the discipline, the circumstances, and the individual student.

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<th>Did you know…</th>
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<tr>
<td>The Internet is an enormous, free, repository of drill and practice exercises. Teachers can mine this resource by doing a Google search for topics such as &quot;math facts games.&quot; Furthermore, most textbooks are now supported by password-protected websites that also contain drill.</td>
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Computers do, however, lend themselves to fruitful drill-and-practice activity. There are many examples of drill-and practice software that effectively prompt the user to practice, over and over if necessary, the skills required to assimilate a particular skill, intellectual or physical. Good drill-and-practice software will provide the user with an opportunity for repetitive interaction and immediate feedback on the accuracy of responses. It will monitor those responses, moving the user forward if the lesson appears to be well learned, and back if responses indicate that the user is over his or her head.

Using the computer for this purpose is doubly advantageous because students have shown, over and over again, that they enjoy interacting with the computer per se, even to the point of having no objection to doing repetitive work, especially when that repetitive work is disguised in the format of a game. The Minnesota Educational Computing Consortium (MECC), established in 1973 to provide educational computer systems for Minnesota’s
schools and since sold, used a game format for its Munchers series of drill-and-practice programs. This game format masks the learning that goes on when children match their math, language, and general knowledge skills at a variety of difficulty levels against Muncher-menacing Troggles. Advancing through levels and facing increasingly difficult opponents are components of many drill and practice applications, including Math Blaster (Fig. 6.8).

![Math Blaster](image)

**Fig. 6.8** Once a "shoot-em" application, Math Blaster now encourages thought and problem-solving as it drills math facts.

**Testing It Out** It is precisely this level of engagement that critics of drill-and-practice software find objectionable. There is often a fine line between "educational" software and "edutainment" software, a line defined by excessive, distracting bells & whistles and by rewards for successful guessing. Teachers selecting such software for classroom use would be wise to test it first, all the way through, and with a student at the controls. It is generally possible to write a software use guide or performance rubric that will maximize learning goals and minimize time wasted in "just playing." It is even possible in most applications to take controls away from the student (although studies show that this is not the most effective learning environment for the most needy students!).

**Moving into the Future** Few educational software developers are focusing their energy on drill-and-practice software alone. The current trend is two-fold: toward "critical thinking" applications that include drill and practice, and toward ILS (Integrated Learning Systems) for the core subjects and skills identified by the NCLB (reading, language arts, mathematics, science), generally focused equally on test-taking skills. These programs will be discussed later in this chapter.
Software for Tutorials

Drill-and-practice software is designed to reinforce known skills, whereas tutorial software is designed to introduce the learner to new skills and concepts. As opposed to ILS, which will be discussed later in this chapter, the tutorial focuses upon a specific curricular content at a specific grade level. In his 2003 review of recent research studies, Kulik concludes that tutorial software (or video) technology can be a "very effective aid" in teaching concepts at both the elementary and the secondary levels (Kulik).

Tutorials take many forms. A student may sit with human tutors who will help him learn a body of knowledge. Or, a student may work with a book that steps him through the exercise of acquiring a body of knowledge. We are interested here in computerized tutorials where a conceptual or skill-based body of knowledge is presented to the user digitally, followed by opportunities to validate the user's comprehension of the concept or acquisition of the skill. The software monitors progress on the basis of the results of validation, taking the user on to new material, or back over old material, in the same way a sensitive human tutor would.

Did you know…

- Probably the most used type of tutorial software is used to teach keyboarding! This software is not disappearing; in fact, it has gotten better with time.
- Moreover…
  - Probably the most popular tutorials found on the Internet teach how to use software! Teachers lacking tech support can make use of these by letting the students teach themselves (and thus each other).

Grab Bag: Tutorial Software

- Fraction Shape-up (Merit Software)
- Super Tutor Chemistry
- How to Read and Understand Poetry
- MindForge Fractions
- Introduction to Patterns (a Tenth Planet product)
- Singing Coach
- Velocity and Acceleration
- Froguts!
- Application tutorials at Atomic Learning (http://movies.atomiclearning.com)

An example of tutorial software is the Rosetta Stone language learning systems, which tutor English-speaking students in the learning of French, Arabic, Chinese, German and numerous other languages. Students use the "immersion mode" to learn language through speaking, reading, writing and listening activities. The system also includes drill-and-practice components—a necessary adjunct of language learning.

In the classroom, a skilled French teacher will incorporate a Rosetta Stone language learning system into a curriculum that uses many other language learning activities—conversation, drama, reading, writing, recitation, dictation, and a drill and practice application. Computer-based tutorials can thus form just one piece, albeit an important piece, of the puzzle that completes the learning process.

Tutorials can also be used independently by students. Kulik found that students in enrichment and gifted programs often recorded the most significant gains from their use.
Chapter 6: Computer-Assisted Instruction (CAI)

Unlike drill and practice applications, then, good tutorials can be used effectively with minimal teacher guidance. The good teacher does, however, monitor student progress!

Moving into the Future Not surprisingly, the Internet is becoming a reservoir for K-12 tutorials, largely through the development of production tools for interactive, multimedia, web-based "learning objects," such as Macromedia's Flash and Shockwave movies, QuickTime movies, and Java applets. Well adapted to focused topics, these tutorials can provide the teacher with much-needed reinforcement and enrichment activities for home or school. Here is a nice example for the curious: take the Cyber Sports Tour (http://archive.ncsa.uiuc.edu/Cyberia/VideoTestbed/Projects/NewPhysics/page_1.html).

A good tutorial presents the goal up front. It also is enjoyable, thorough, and sensitive to the user's capabilities. Moreover, it either provides immediate and appropriate feedback (similar to that found in drill and practice applications) or provides opportunities to stop and review as many times as necessary. Interactivity is key to user involvement and perseverance. It is no wonder that all aspects of education, pre-K to postgraduate (including medical schools), commercial and public, are embracing this new use of technology for CAI.

Software for Simulations and Gaming

Simulations are powerful tools for learning. They involve the learner in a vicarious experience of events or processes, a kind of "trial run on reality" (Bruner, 1966). As such, they marry nicely into a constructivist or inquiry model of teaching. Students experience something closely related to real life through the simulation, depending on how well it is done. Many digital simulations can be experienced over a network, others are designed to run on individual computers. Both formats lend themselves to collaborative learning, developing communication and interpersonal skills as well as knowledge. Software such as the Oregon Trail™, originally created by MECC and now published by The Learning Company, and The Maxis Sim series of managerial strategy games—such as SimLife, SimCity, SimEarth, and SimAnt—were developed as role-playing games which simulate life in various environments.

There is no doubt that simulation software such as this adds a fascinating, engaging, and virtually realistic opportunity to learn about history, life or scientific phenomena.

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<td>Hot Dog Stand/Ice Cream Truck</td>
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<td>Sim (series) - Earth, Planet, Farm…</td>
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<td>Eyewitness Virtual Reality</td>
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<td>Decisions, Decisions (series)</td>
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<td>The Great Solar Rescue</td>
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<td>Virtual Physics Escape from Braindeath</td>
</tr>
<tr>
<td>Sammy's Science House</td>
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<tr>
<td>Juilliard Music Adventure</td>
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<tr>
<td>Geometer's Sketchpad</td>
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<tr>
<td>GollyGee Blocks</td>
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<tr>
<td>Neighborhood Map Machine</td>
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Because of their power to engage the learner, simulations are not new to education. Elementary age students build houses, factories and post offices. Middle school students reenact the Constitutional Convention, stage Medieval Feasts and reenact Plymouth Plantation and Colonial Williamsburg. High school students debate pressing historical and cultural issues. The goal is to help students to develop deeper understandings through total engagement in the activity, the moment, the idea or the event.

Simulations, whether computerized or not, whether tutorial or discovery in nature, are most effective when a realistic range of feedback accompanies the interaction. Commonly available CAI simulations for high school suffer from being somewhat removed from reality by the limitations of a relatively flat computing environment.

When students simulate the dissection of a frog on a computer, for example, they are deprived of the tactile and olfactory feedback experienced when dissecting a real frog in real life. Using the simulation, students learn the correct steps in the procedure, but they miss out on the experience of critical facets of the task. This is all well and good if the students are not expected to go on to become Intel scholars. But if they are, they have to learn in a more realistic environment.

Teachers at the high school level must be sure to select simulation applications that do not "talk down to" students through silly graphics, simplified text, and simplified challenges.

One subset of simulations that does challenge and engage high school students is computer modeling based upon probabilities. Students using tools such Model-It from Go-Know analyze the effects of several environmental and random factors upon a population or environment that can be graphed over time. When coupled with a study of actual data, as for the spread of an infectious disease, this is a powerful learning tool.

Simulation applications have existed for many years to support the study of high school mathematics. The "graphing calculator," originally a creator of simple line graphs, is now able to produce animated 3D graphs and visualizations of complex algebraic and calculus equations that respond to student manipulation, graphs that students could not possibly produce by hand.

Simulations can be powerful tools in the elementary and middle school environments, where students have little difficulty suspending disbelief and often become engrossed with software that steps them through a science experiment, an historical sequence of events, a mathematical investigation, a business transaction or a imaginary journey in an impossible place. Along the way the students are prompted for feedback, which monitors understanding and points the way to deeper learning. Simulations are the basic element of the WebQuest, a web-based research and thinking project model that will be discussed in Chapter 9.

In addition to the Internet sites that will be discussed in the next section, an important example of online simulations can be found at The National Library of Virtual Manipulatives (http://matti.usu.edu/nlvm/nav/vlibrary.html), which supports k-12 standards-driven math instruction with interactive simulations (Fig. 6.9 on the next page).
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**Virtual Field Trips** Another interpretation of the concept of simulation is related to what are described as Virtual Field Trips or electronic field trips. Examples of some of the best have been gathered together by Right in Class—Classroom Connections (http://www.rightinclass.com/connections/virtual_tours.htm), which also provides teachers with access to synchronous virtual trips, or live webcams, around the globe. Another list is provided by Kim Foley at Tramline Virtual Field Trips (http://www.fieldtrips.org/trips.htm). These e-field trips are designed to give the visitor to the website an educational tour of the content. In many cases, the content is tied to state and/or national curriculum standards. Visitors can earn about subjects such as Rainforests, Endangered Species, Salt Marshes, Volcanoes, Shakespeare, Presidents, Pi and so forth. Teachers’ objectives and resources for each trip are often provided. The wise teacher will take the tour herself, timer and activity sheet in hand, before introducing it to her class. Some teachers will use a virtual tour of a museum to prepare students for the actual tour, focusing them upon the important exhibits and providing background information.

**Moving into the Future—Virtual Reality** VR brings simulation into real time. At the simplest level, Apple’s QuickTime Virtual Reality (QTVR) program enables the creation of 360° panoramic views of objects. Using the mouse, this application allows you to rotate 3D objects such as molecules, sculptures and photographs.

More and more websites use QTVR in order to display objects related to the content of their pages--museums and art galleries, for example. Perhaps the most exciting educational uses of this technology are 3D tours of real archaeological sites, such as the PBS guided exploration of the Great Pyramid (http://www.pbs.org/wgbh/nova/pyramid/explore/khufuenter.html); and the 3D modeling of virtual chemical models, such as those found at the Biomolecular Explorer 3D (http://www.umass.edu/molvis/bme3d/). VR, then, is a powerful tool across the k-12

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16 Objects have been photographed in a 360° circle or created with 3D modeling software.
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spectrum. Note, however, that like most of the other new tools we have discussed in this chapter, VR images are generally accessed over the Internet.

In the gaming and the high-tech training environments, the user often dons headgear or special goggles to view computer generated images of some pre-determined simulation (such as a voyage to the bottom of the ocean or an airplane landing). The player or trainee reacts, via joystick or instrumentation, as if he or she were actually performing the task in the real world. In the modern classroom, students can now use computer keyboards, touchpads and voice controls to manipulate remote cameras and robots and move through simulated environments. Students can get healthy with Dance Dance Revolution or control a virtual keyboard using WII or other remote technologies. We will have to wait and see whether or not headgear and joysticks become part of the school environment as well.

**Virtual Worlds** There are a fast-growing number of "virtual" worlds on the World Wide Web, where students have the opportunity to construct knowledge about some segment of the knowledge spectrum by wandering around in a virtual community. One example is Howard Hughes Medical Institute's *BioInteractive* virtual labs ([http://www.hhmi.org/biointeractive/vlabs/](http://www.hhmi.org/biointeractive/vlabs/)), where students can participate in a variety of learning modules focused upon medical and biomedical research.

*vRoma* ([http://www.vroma.org/](http://www.vroma.org/)), a virtual exploration of Ancient Rome, is an example of yet another virtual simulation, the MUD (Multi-User Dimension), in which students take on personalities and interact with other "citizens and visitors" to the city. *Second Life* ([http://secondlife.com/](http://secondlife.com/)) is a similar virtual world, in which members move around, create spaces, and interact in the form of avatars. This technology is well adapted to history study, for students, by role-playing "real people" in a highly charged historical place and time (pre-Revolution Boston, for example), learn that the study of history is more than the collection of facts and dates. The line between gaming and virtual worlds is very thin, and teachers should look out for more “game-like” teaching applications in the future.

Elementary school girls love to explore the virtual world called *Neopia* ([http://neopets.com](http://neopets.com)), where they can purchase Neopets, chat, invest in a virtual stock market, and compete against other Neopians. Its success is driving the development of more educational virtual worlds.

There is no doubt that educational computing has barely scratched the surface of potential applications for rich learning experiences of a simulated or virtual nature. The creation of such worlds is time-consuming and a technological challenge, however. For this reason, teachers must rely upon universities, developers and

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17 Not recommended for classroom use, but worth a look!
high-tech institutions to create the content. Furthermore, research findings are tentative with regard to the educational value of simulations in the classroom. Teachers are wise to use them with caution.

In the meantime, teachers who have access to digital production hardware and software can guide their students in the creation of their own simulations and virtual field trips—learning experiences that can then be shared with other classrooms. We took a peek at GollyGee Blocks earlier in this chapter, one simple tool for creating virtual spaces, and we will explore more tools in chapters 9 and 10.

Software for Critical Thinking and Problem Solving

A straightforward definition of Critical Thinking (CT) is offered by Ennis: it is "reasonable and reflective thinking focused on deciding what to believe or do." (Ennis, 2002). In his essay, "Critical Thinking: What it is and why it counts," Peter Facione states, "critical thinking came before schooling was ever invented, it lies at the very roots of civilization. It is a corner stone in the journey human kind is taking from beastly savagery to global sensitivity" (Facione, 1998). Powerful stuff. It is no wonder that educators continue to wrestle with how, when, and to what extent CT should find its way into the k-12 curriculum. Increasingly, software and web developers are stepping up to meet this need.

Every teacher learns quickly that guiding students to develop strong Critical Thinking skills is perhaps the most important task of all. In the practical world of the classroom, self-confidence, bullying, harassment and peer pressure are as important as facts. Students must learn to navigate not only their personal worlds, but also the media world and the larger global community, each of which requires that reason, reflection and self-judgment be applied daily to complex and often painful decisions. And yet, because the focus of CT is not just upon solving problems and finding answers, but also upon becoming a better person through doing so, it is difficult to define the exact role of CT applications within the realm of CAI. Although tools exist to measure CT skills, they are not part of the assessment toolkit of most elementary and secondary schools; although there are often statewide standards for communication and decision-making, data-driven testing is not in the state toolkit.

That said, good computer applications exist to guide students, generally with the assistance of tutorials and simulations. The software itself, of course, will not teach Critical Thinking, but when used by a good teacher it can support, and sometimes jumpstart, the thinking process.

Thinking skills, like their subset problem-solving skills, can be learned. The development of what is often called "lateral thinking," or "thinking outside of the box," goal setting, and the logical thinking involved in analysis, inference and evaluation are important elements of Critical Thinking. The Thinkin' Things® and the Zoombinis™ series develop these skills

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18 One is the WGCTA, the Watson-Glaser Critical Thinking Appraisal
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by presenting students in elementary and middle school with increasingly complex problems to solve—problems that are engaging but also hard.

Fig. 6.10 The Zoombinis face many critical decisions

Tom Snyder's *Choices, Choices* series for grades k-5 guides students in "smart" decision making by placing them in realistic scenarios, such as on the playground. The Critical Thinking Company (http://www.criticalthinking.com) produces more traditional software that brings a reasoning approach to the development of mathematics and reading skills, k-12.

Another type of CT software is represented by *The Incredible Machine*. This product requires that students, preferably working in teams, solve a set of design challenges using logical steps. As is often true in the real world, there is no one right way. *MicroWorlds*, LCSI's *Logo*-based application series, requires even more of the students; they must *create and then solve problems* using the *Logo* programming language and a multimedia toolkit. When these problems simulate a rainforest food chain or the attack of a killer virus, the thinking can become critical.

It should come as no surprise that graphical organizers are powerful tools for developing Critical Thinking skills. Brain-storming encourages open-mindedness; mapping a concept or argument visually facilitates its analysis and evaluation. Using a tool such as *Inspiration* along with a WebQuest, reading lesson, history discussion or software application is an effective teaching strategy.

Lastly, you will remember that in Chapter 5 we touched briefly on the use of computer applications to assist teachers with student guidance issues. This too involves CT, and may be the best solution for high school students. Most students today will seek self-help on

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19 As Seymour Paper reminds us in his book *The Connected Family*, the best learning is "hard fun." (Papert, 1996)
the Internet; teachers who familiarize themselves with helpful sites²⁰ and learn about the advantages and disadvantages of social networking and chatting will, in a quiet way, help students to build Critical Thinking skills. In fact, an open source application, Ning, can be used by the teacher (with tech support) to build an in-house virtual world – where the actions that come from thinking can be practiced and (somewhat) moderated.

In sum, it is not the application, but the application of the application that develops Critical Thinking. Any one of the applications or websites discussed in this chapter can become a powerful tool for CT. Returning once again to Jamie McKenzie, it is all about the Questions and, for the teacher, probing for and listening to the Answers.

Software for Supporting Learning

Almost all of the applications discussed so far can be used to differentiate instruction. Most can be used at various levels and with a wide range of learning or productivity outcomes.

There is another category of application, however, that can be described as “support software.” It exists to make learning through technology accessible to all students, assisting instruction at the point where it is most needed – at the level of the individual student interacting with the computer. We will only introduce some common examples.

Many of these applications are specialized “assistive technology,” designed to meet the needs of specific disabilities identified by testing. Software translating a simple two choice input device into an alphanumeric display (writing) is an example of this.

Early readers can use applications such as Clickr that prompt the writer with a picture or a word list.

Others, however, operate in the background on most computers – and are used quietly all the time. Because of this, teachers should be aware of these “stealth CAI” applications.

Perhaps the most ubiquitous are the dictionaries and thesauri contained within applications and also stored as applications on a hard drive. Many other dictionaries can be found online. A related set of applications are the translators, used in language classes, but also by ELS and ELL students. Most operating systems make multiple keyboards available to support multiple language spellings and characters.

Other examples of support applications are text-to-speech and speech recognition applications. Both are helpful for the visually impaired and for students with learning difficulties that make reading difficult or tedious. Similarly, voice recording applications make it possible for a student who can not easily keyboard to produce lengthy essays or high quality tests.

Teachers must teach ALL students in the classroom. Knowledge of these support applications can make the difference between success or failure for many students!

²⁰ A good place to start is the Teen Space in the Internet Public Library (IPL), where teens and teachers can find selected sites on topics such as Issues and Conflicts, Health, and Dating and Stuff (http://www.ipl.org/div/teen/). KidSpace is available for elementary and early middle school (http://www.ipl.org/div/kidspace/).
Probes, sensors, digital microscopes and similar data capture devices have long been essential components of scientific experimentation. Their purpose has been to augment the highly sophisticated, built-in, yet inadequate instruments represented by our five human senses. The scientific method, whereby "a problem is identified, relevant data are gathered, a hypothesis is formulated, and the hypothesis is empirically tested" (Webster’s, 1991), is applied differently depending on the discipline. But, at its core, it is concerned with the measurement of phenomena through experimentation or repeated observation.

Scientists at all levels recognize the value of the computer-based laboratory (CBL) for research. They have developed hardware and software systems that automate the process of gathering data from experiments, conduct relevant analysis, and produce meaningful reports. We have only to watch CSI to learn the impact of speedy data analysis on problem-solving and critical thinking.

Schools preK-12 are using computers to involve even the youngest students in the capture and analysis of considerable amounts of data. In elementary and secondary school laboratories, science meters and probes automate the collection of temperatures, pH and other information, a process that can continue 24 hours a day. As a result, far more experimental data can be collected and cross-referenced than was possible in the days of manual data tracking. One of the most valuable aspects of the CBL is the ability to do real time graphing of data captured in an experiment. Complete data sets can be stored for further analysis and shared over the network or Internet. The collection of physical data, such as the measurement and analysis of images of real objects (leaves, proteins, fibers), is accomplished with digital imaging tools such as the ScalarScope and the high resolution digital camera with specialized imaging software such as ImageJ. Such images are replacing hand-drawn sketches and the preservation of samples.

It is no surprise that the Internet is a vast resource for science data in all academic areas. Schools lacking hardware resources can perform virtual experiments and mine data sets posted by partner schools, universities and the government. Data analysis is becoming an important part of the global science lesson.

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21 You will sometimes find these referred to as MBLs, or Microcomputer-based Laboratories.
Handheld Laboratories A subset of the traditional CBL is the handheld learning environment, made possible by advances in microcomputing and reduction in the physical size of memory\(^{23}\). Most probes and sensors require an intermediary device to interface with the computer\(^{24}\). Often this is a PDA, or handheld device. A huge advantage of this technology is its "field-ready" nature. Students participating in one of the CIESE Real Time Data Projects (http://www.ciese.org/realtimproj.html) or one of the collaborative GLOBE projects (http://www.globe.gov/fsl/html/aboutglobe.cgi?intro&lang=en&nav=1), for example, can complete data sampling exercises, take digital images, enter, merge and graph data in the field. Results can then be downloaded to a desktop or laptop computer, further analyzed, and shared with the global community.

Another hand-held, or rather machine-held, interface is the mini-computer Cricket or RCX brick, central to a robotics program. Probes attached to student-constructed, programmable robots collect "field data" that is downloaded to a computer workstation for analysis. Students can simulate Mars Rover exploration, for example, programming their bots to respond to changes in landscape and obstacles.

One other technology is making its way from the public to the educational sphere. GPS/GIS\(^{25}\) systems have long been used by hikers, boaters and drivers to assist with navigation, and by archaeologists, meteorologists and rescue workers to plot field data. The availability of satellite images, previously available only to the government, has made it possible for students to learn geography and mapping "in the field" using handheld instruments, many of which have realtime cellular connections. Students as young as elementary school participate in environmental mapping activities and scavenger hunts. These activities not only require that students use the scientific method and critical thinking skills—they are fun!

Another common use of handhelds in the classroom is made possible by the development of inexpensive graphing calculators that interface with, and download directly to, classroom computers. Used originally for high school mathematics, these devices, such as the Texas Instruments TI-89, connect to the same probes that can be used with PDA devices and laptop computers. Courseware is available to support their use in both middle and high school, in both the mathematics and science curricula. Of course, the graphing calculators are powerful microcomputers in their own right. Some schools use only handhelds!

Portability is clearly an advantage of the new CBL. Wireless and cellular networks, handheld technologies, voice recognition and digital imaging are making the collection and analysis of real time data accessible to all students. In addition to changing the way we teach, some of these activities may change the way we live our lives\(^{26}\).

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\(^{23}\) Just think about the changes in cellular phones over the last five years!

\(^{24}\) The EcoLog (http://www.dataharvest.com/Products/ecolog/ecolog.htm) is a self-contained unit.

\(^{25}\) Global Positioning System and Geographical Information System

\(^{26}\) The newest generation of cellular phones is moving us closer to change!
Programming and Problem-Solving

Interesting discussions have been published on the issue of whether or not computer programming (in Logo, BASIC, or Java, for example) helps develop problem-solving skills—Papert (1980), Turkle (1984), OTA (1988), Capper (1988), Apple Computer (1990), Kearsley (1992), Ennis (1994), to mention but a few. The consensus is that the practice of computer programming does not necessarily help when it comes either to learning problem-solving in general or mathematics in particular. Nor does it help in preparing teachers to teach mathematics. Ennis (1994) concludes, with Lehrer and Smith (1986), Littlefield et al. (1988), and Govier (1988), that "instruction in problem-solving helps facilitate the learning of problem-solving." Period.

Turkle (1984), in the context of child programmers, asks the question: "Do computers change the way children think?" Turkle's answer is another question: "What do different kinds of children make of the computer?" The implication, of course, is that the computer can tell us more about the nature of children (through their mode of interaction) than it can affect that nature. Computer literacy in general is very important from the perspective of employability, but programming per se is only a small part of this employment picture. Current IT skills focus more upon networking, hardware, software, information management and telecommunication tools (such as integrated web-based solutions). Why then teach programming?

Problem solving is a key. Earlier in this chapter we discussed this in terms of Critical Thinking, where it is a component of the universal k-12 experience. Another, real-world answer is suggested by the simple fact that someone is doing the programming of every computer application, and this is still considered the most skill-intensive of all IT tasks. Employers who do not find a skilled job pool in-country are seeking it elsewhere. Programming skills are sought-after job skills in the global community.

Logo There does appear to be support for the Logo programming language as a medium for developing non-verbal cognitive skills such as creativity and independent learning, described by OTA (1988) as "the ability to monitor and evaluate one's own thinking processes," and the "ability to provide accurate descriptions"—both of which are essential Critical Thinking skills.

You may recall that the Logo computer programming language, developed by MIT's Seymour Papert, was a by-product of his work with Jean Piaget, the famous Swiss psychologist and educationist, with whom Papert studied. Logo's graphics-based interface, which uses a simulated "turtle" as a vehicle for programmed instructions, is enjoyable, and therefore motivational for children (Kearsley, 1992). This facilitates early introduction to relatively advanced programming concepts, such as recursion (procedures or functions that "call" themselves), variables and conditional statements. Logo also indirectly

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27 This brings to mind the common reflection of sports coaches who say that the best place to learn about children's personalities is on the playing field.
motivates the student to think independently along conceptual lines that lead to the acquisition of geometric and other problem-solving skills (Turkle, 1984).

*Logo* spin-offs, such as the multimedia authoring application *MicroWorlds*, Alan Kay's freeware *Squeak*, and the Lego Logo and MindStorms robotics programs, have renewed the dialogue about the value of *Logo* in the elementary and middle school classrooms by combining its use with the creation of collaborative and student-controlled virtual worlds and simulations. What students program to learn or explore is more important than the acquisition of the language itself, to the detriment, perhaps, of future enrollment in AP Computer Science courses (which remain firmly rooted in programming languages, albeit now OOP—Object Oriented Programming).

*Logo* aside, we have seen in this chapter how problem solving is currently well represented by non-programming computer applications and web-based activities. It would be difficult, in fact, to teach a technology-integrated lesson that did *not* have a significant problem-solving component.

**Integrated Learning Systems**

The passage of NCLB, as noted elsewhere, has driven the development of standards-driven educational support systems, one type of which is the ILS. The "truly" integrated learning system would be "a system for learning [which] would make available a variety of appropriate activities, well-integrated and well-suited to a learner's interests and capabilities" (Komoski, 1990). About the only integrated learning system that currently fits this description is a good school.28 A system such as Komoski imagines is too complex to be a reality at this time. In practice, therefore, an Integrated Learning System is a comprehensive networked instructional system comprised of courseware which is integrated with whatever textbooks a school requests, or which replaces selected texts, along with standardized and non-standardized student assessment vehicles which have built-in individual and group student-progress reporting functions.

As Sherry (1992) notes, a good ILS includes courseware for a broad range of learning experiences, including simulations and online or self-contained vehicles for research. Not surprisingly, the ILS is now predominantly an online system.

A growing number of companies offer ILS for this burgeoning market. We will profile the products of two companies: CompassLearning (originally Josten's Learning) and RiverDeep's Destination modules.

**CompassLearning** Among the most comprehensive ILS's are those offered by Compass Learning Odyssey. These are curriculum modules for every age group from pre-K through 12, providing a standards-based, web-based solution in reading, mathematics, writing, social studies, ESL, special needs and interdisciplinary topics. Not just information delivery systems, these modules provide explorations through texts, experiments, simulations, guided research, and problem-solving activities. In fact, like all good ILS's, CompassLearning Odyssey uses all of the CAI strategies discussed in this chapter. Its goal

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28 Teachers should keep abreast of local and statewide home schooling, distance learning and other "out of classroom" options for students.
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is to improve standards-based instruction by teaching to all learning styles and all intelligences.

Activities are largely online, but each module includes offline activities as well. Online assessment aligns learning to state and national standards; individualized reports indicate strengths and weaknesses and suggest remediation and learning paths. Data management is entirely web-based and is accessible to administration and teachers. All facets of the solution can be customized to meet the needs of the school, teacher, or district. Although the solution is web-based, it can be mounted on local servers, allowing the school or district even greater flexibility.

**RiverDeep Destination Math and Destination Reading** Another interesting k-12 ILS solution has been developed by RiverDeep. Like CompassLearning Odyssey, these provide fully developed curricula in core literacy content areas. Destination Math is a k-12 curriculum. Following an initial assessment, students work through a sequenced curriculum that is correlated to state and national standards and the "top" basals (most used). The math curriculum is delivered in seven modules, each covering more than one traditional grade level. Destination Reading is a k-8 solution focused upon the development of reading skills.

Both RiverDeep ILSs provide individualized assessments and data management and use multiple CAI technologies in the instruction. Unlike CompassLearning, however, the focus of the RiverDeep ILS is clearly to improve standardized test scores.

ILSs such as those described above are not easy to implement in the school. First, they are often cost-prohibitive, although federal funding is available under NCLB and other grants. Second, computers must be available to students, generally in an instructional lab. Next, teachers must be trained to use computers, the Internet and the networks for instructional purposes. Last, teachers must be trained again in the use of the ILS. Although most teachers, given the opportunity, will take advantage of an ILS by incorporating aspects of the system into the curriculum, only those with considerable computer background and considerable support will take full advantage.

It is not surprising that Dr. Henry Becker, who has conducted considerable research in ILS, observed that the most effective users of ILS's were teachers who "knew the most about the system, knew the most about what the kids were doing in the lab, and went back to the classroom and made decisions about what to do based on that information" (Mageau, 1990). As with so much computer-based teaching and learning, these ILS have much to offer, but there is still a way to go before they can be incorporated seamlessly into the k-12 curriculum. Technology that adds to a teacher's time or subtracts from effective teaching is not going to be successful. Teachers should be aware of the current trend toward data-driven education, and thus toward programmed teaching, and apply their own critical thinking skills to its evaluation and implementation.
SOFTWARE EVALUATION

It is important that teachers be able to evaluate the effectiveness of the CAI material that they plan to use in their lessons, even if it has already been evaluated by others. The stamp of approval that someone else puts on an application should encourage teachers to carry out their own evaluations.

Teachers may read reviews of a learning system in a journal; but as pointed out in OTA (1988), journal reviews tend to be positive, if only because they rely on advertising revenue for their survival. Teachers may read sales literature written by the creator or distributor of the system; but this also has the problem of subjectivity. Increasingly, teachers may solicit review and teaching ideas from online colleagues.

No matter what the source of an evaluation, it cannot compare to the evaluation that teachers conduct themselves, for teachers know their students—their backgrounds, their capabilities, their learning needs. Thus teachers can best decide what methodologies will work with students. Teachers must take upon themselves the responsibility to evaluate the CAI they decide to use. Having done so and, in the process, tried out the systems with students, teachers have a responsibility to share their experiences with others—immediate colleagues or, in the broader forum, with colleagues in classrooms everywhere.

The Design of Effective Software Evaluation Instruments

A software evaluation checklist is a prerequisite to the selection of the best from among the rapidly expanding database of available educational software. As with all teaching materials, educational software selection will be affected by the characteristics of the population for which it is intended. For this reason, a software evaluation checklist should be drawn up locally with the help of local teachers and students. In this way, software that is selected will more likely be appropriate to local needs.

A software evaluation instrument is essentially a data entry form. As such its design should reflect the known human factors characteristics of effective data-entry instruments. The following set of guidelines will help in the design of an evaluation instrument appropriate to local needs. Some of the recommendations come from Bailey (1989).

Remember that the people evaluating the software are busy. The easier it is for them to fill out a form that provides useful data, the better. Schools may find that a handheld, web or network-based database facilitates the evaluation process. Others will find that a printed form works best. Here are some basic guidelines for making your own form:

- **Keep it simple** Explain technical terms if necessary. Use familiar words, even local dialect, to make the form easier to read. Keep questions brief. Short sentences are easier to follow than long ones. Make the form easy to fill out; the user should not have to write sentences in response to anything, except, perhaps, for the final open-ended freeform question: "Any other comments?".

- **Keep it brief** The evaluation should be no longer than two sides of a single sheet of paper.

- **Make it easy to follow** Include summary evaluation data at the top of the form to assist in first pass selection—a star rating (with legend), subject area, appropriate
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age group. Break up evaluation criteria into categories and use topic headings to guide the user. Use dots or the underscore character to visually align with each question the space allocated for each response. This response space should not be boxed, it should be lined up with other responses, and should be as close to the end of the question as is convenient for easy reading.

- Make it forward-thinking A form that can handle the evaluation of web pages as well as software applications will perform an even more valuable function in the future.

- Make it attractive Use plenty of white space on the page, especially between sections and between lines. Handwriting needs a minimum 1/4" of vertical height. Depending on the font you use, don't use a point size (the height of the characters) less than 12. Try not to crowd the questions. Top, bottom, left, and right margins should be a minimum 1/2". Use no more than two fonts. The model form in Fig. 6.12 uses a sans serif font for headings, and a serif font for the rest.

- Make it available If a hard copy (paper) is more convenient than a digital database, prepare a set of forms on paper and make them available to teachers and students. Have a box nearby large enough to hold 8 1/2" by 11" paper. Also set up an on-line database for easy referral.

The Process of CAI System Evaluation and Purchase

Here are a few recommendations to guide you in the process of software evaluation and/or software purchase. Some of these ideas are drawn from Apple (1990).

- Plan ahead Draw up a list of needs: What is the age group and subject area for which the software is required? What criteria may be necessary to fit your teaching style? What kind of CAI software do you prefer for your students? Will it be used in a classroom or lab setting? What hardware and operating system must it run on? Will it be used on a network? If so, will it be installed on a server or on individual machines? Will users need ongoing Internet access? Will they need support applications, such as media players? Do you have headphones for student use?

- Be a "review-worm" Subscribe to journals (computer or otherwise) and bookmark web pages relevant to your responsibilities and interests in the education field. Scan them from cover to cover. Read reviews of products that might meet your needs.

- Preview software Always try to preview software before buying it or subscribing to an online application. Many software producers make demo versions available for download on a website. Seek out local schools that might have the software already if you can Contact the producer directly if you have a question. If you have no opportunity to try out a product on your system, you probably should not buy it.

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29 Demo versions can be either "full featured" or limited. Most will automatically expire, or lock, in 15 to 30 days or after a set number of uses.
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- **Check out the software** Always run through the software at least once yourself. Fill out the evaluation form. Then, if you still like it, have other teachers or students use it, too, and get their feedback by having them fill out an evaluation form.

- **Check the license agreement** More companies today are agreeing to let teachers have a copy for use at home (or on a laptop) as well as at school. Site, network, and "lab pack" licenses are also well worth negotiating.

- **Negotiate hard for the lowest price possible** Multiple copies should be discounted. The recommended retail price is rarely the same as the educational price.

- **Purchase educational versions**, not "home versions," where possible. These will contain instructional manuals and standards alignments to support you.

**LOOKING BACK**

In this chapter, we have examined many aspects of CAI. It is beyond the scope of this book to profile even a tiny proportion of the ever-growing base of CAI applications that are being used to supplements education in our schools. The fact that a piece of software or a website is available for integration into the curriculum does not automatically make it appropriate or effective. Teachers have the responsibility to determine what, if any, applications will be appropriate for their classes. They cannot do this unless they give the technology a chance.

This and the previous chapter have tried to present the characteristics of CAI, along with tools for software evaluation and recommendations for successful incorporation of the technology into the teaching and learning process. But the real work begins when teachers get their hands on the technology and start to "learn by doing." Such an opportunity should be integral to any teacher-education program and, since you are taking this course, it is good that it is part of yours.

**LOOKING FORWARD**

Chapters 7 through 10 will continue to examine practical aspects of computer-based teaching and learning. The focus in chapters 7 and 8 will be computers and communications (C&C)—networked computing—and its impact on schools, today and in the future. Chapter 9 will examine the tools of online learning. Chapter 10 will then examine all aspects of multimedia.

As will be seen, we have barely begun to scratch the surface of the methodologies for instructional delivery systems enabled by C&C and multimedia technology. Fred D'Ignazio (Bruder, 1992) reminds us that "education is a faddish profession" (like any other), but there are times when it is reasonable to predict that some fads will endure longer than others. Computer technology in the classroom is one of these and, like computer technology in the other professions, it will transform education in ways that may seem beyond our wildest dreams.
Chapter 6: Computer-Assisted Instruction (CAI)

Successful innovation in schools cannot happen without strong and enlightened leadership. The best leaders involve everyone—teachers, parents, administrators, and students—in the process of change and renewal. As noted in Joyce (1993): "Two extremely important dimensions of strong leadership" are the ability to generate a collaborative community and the ability to diagnose the essence of problems, solve them, and lead others "to find needs and create solutions." Schools and school districts are almost totally dependent on the quality of their leadership. Superintendents and principals with true leadership skills have shown again and again that ordinary schools can triumph over the most difficult circumstances and compete effectively with the most privileged schools in the world.
Chapter Seven
Computers and Communications (C&C)

Technology is rapidly reducing the communications barrier imposed by distance to a state of near irrelevance. Today, physical barriers matter far less than the logical barriers that separate sources and users of data.

_Arno Penzias, Nobel Prize Winner and for 37 years Head of Research at Bell Labs (1933- )_

Modern technologies are space collapsers, time shifters, and creative tools that extend our reach.

_David Thornburg, founder and Director of Global Operations for the Thornburg Center_

LEARNING OUTCOMES

Until about 1995, electronic communications technology had only two applications in most elementary and secondary schools. It was used as an administrative tool in the form of the telephone, and it was used for educational programming through the medium of television. Today, however, triggered in large part by the explosive expansion of the World Wide Web, computers are enabling new uses of communications in schools. As more computers find their way onto teachers' desks, onto the students' desks, and into teachers' and students' homes, computer-based communications networks provide opportunities for electronic interaction, opening up pathways to knowledge and social interactions which are changing the way education is done.

This chapter will look at the nuts and bolts of computers and communications (C&C) in order to provide a context for its tidal wave of use in education. The next chapter—chapter 8—will then examine Distance Learning and, more specifically, the phenomenon of the Internet, of which the World Wide Web is an integral part. An inevitable by-product of the ubiquity of access to the web is a dramatic increase in online learning—learning that “happens,” often spontaneously, as a result of children’s immersion in the online world, whether at school or at home. Chapter 9 will go on to examine those online learning tools that are currently relevant within the context of K-12 education.

First we need to take a look at the scope of communications—what comes under the umbrella of communications and how communications affects K-12 education. It will be useful, too, for you to gain a basic understanding of networking technology—the electronic highways along which all the data flow. Finally, in this chapter, we will apply the lessons gained from the _TransParent_
Chapter 7: Computers and Communications (C&C)

School Model, which relies on already generally available communications technology (the telephone), as well as computer-based communication models.

Specifically this chapter will cover the following topics:

- The Scope of Communications
  - Computers and Communications (C&C)
  - Technology Transfer and the Challenge Posed by User Demand
  - Explosion in End-User Computing
  - The Expansion of C&C in Schools
  - A Vision for the Future
- Computer Networks
  - Computers
  - Communications Channels
  - Modems and Fax/Modems
  - Other Communications Hardware and Software
  - Different Kinds of Computer Networks: LANs, WLANs, WANs and MANs
  - Applications of Computer Networks
    - Telecommunications
    - Hardware Device and Software Sharing
  - The Case for Computer Networks
  - Implementing Computer Networks
  - Recommendations for Successful Introduction of Computer Networks in Schools
  - The Impact of Computer Networks in Education
- Home-School Communications
  - Schools Need Parents
  - Parents Need Help, Too!
  - The Schools Must Take Responsibility
  - The Importance of the Student-Parent-Teacher Gestalt
  - The TransParent School Model
  - Outcomes of the TransParent School Model
  - C&C Today - Extensions of the TransParent School Model
  - The Importance of Choice

THE SCOPE OF COMMUNICATIONS

Communication—the exchange of data within and between species—is nothing new. Amoebas do it, trees do it, cats and dogs do it, and so do we. Species survival depends on it. The human species, like most other species, uses language to communicate. Language involves verbal as well
as non-verbal cues. Humans have developed an incredible variety of spoken and written languages; we also smile, laugh, grimace, pout, cackle, and cajole.¹

Over the years, we also have devised quite a range of technologies to communicate with people who are not close enough to see or hear our unamplified communication. We have used drums, we have yodelled, we have sent runners, we have made smoke signals, we have used flags, we have attached messages to arrows and used bows to fire them from point to point, we have used carrier pigeons, we have organized relays of ponies.

Once we discovered electricity and figured out how to use it for communication, we devised a system for sending coded messages across vast distances at close to the speed of light.

Enter Communications—with an ‘s’.

Communications is actually an abbreviation for Telecommunications. The prefix ‘tele’ means ‘far distant’ from the Greek. Communication (without the ‘s’) refers to the act of communicating, whether near or far and no matter how it is done. Communication includes Communications (with the ‘s’). Communications refers to distance communication of data over electronic media. The data may be in verbal, written, coded, pictorial, audio or video form.

Computers and Communications (C&C)

Computers can be either standalone, that is to say unconnected to other computers, or networked. The problem with standalone computer systems is their isolation. Users of a standalone computer cannot take advantage of communications facilities such as electronic mail (e-mail), on-line chat, on-line data retrieval, and data sharing. Thus the writing is on the wall for computer systems that are unable to connect to a network. Today, any computer you buy has connectivity built in. You can still use the computer in standalone mode—you don’t have to be connected. Indeed, there will be times when you don’t want to be connected—either because you would have to pay a toll or because you simply don’t need to use any online services such as the web or e-mail. But for the most part, connectivity is becoming the norm.

One of the most important high tech trends in recent years has been the interlacing of computers with communications (C&C). In the 1960s, computer networks were built around mainframe and minicomputer hubs. In the 1970s, microcomputers arrived on the computing scene, and by the mid-1980s these desktop computers were being co-opted into service as communications tools. The 1990s saw the rise of the Internet. Leaps in satellite and telecommunication technologies have now made mobile computing, cellular phones and wireless networks almost as common as the home land-line telephone once was. Technology and communications businesses are actively seeking ways to continue and extend these growth trends. As we saw in Chapter 5, networked computer use in schools is becoming ubiquitous. Harnessing new, portable and relatively inexpensive technology resources for communication purposes is one of the tasks facing schools today.

¹ The C&C versions of these gestures are the smiley (an icon) and the emoticon (a set of typed characters). Learn more at the Acronyms, Smilies and Emoticons Page (http://www.muller-godschalk.com/emoticon.html). Even more sophisticated are today’s talking, gesturing avatars. An avatar is a graphic representing an online users.
Chapter 7: Computers and Communications (C&C)

Technology Transfer and the Challenge Posed by User Demand

Technology transfer is the process whereby technology finds its way from the work bench of the inventor into the hands of the everyday user. With regard to computer technology, this transfer has accelerated rapidly as computers have become inextricably associated with communications systems. Birnbaum (1985) pointed out that computer technology, by 1985, had entered the third of the classic four phases of technological evolution.

- The electronic computer was "manufactured in quantity"—phase one.
- The computer had "become well known and commonplace"—phase two.
- But the computer was "used directly by only a rather small portion of the population"—phase three.

This was especially true in schools, where tight budgets severely restricted the spread of computer use in the classroom. The advance to the fourth and final "pervasive" stage, when "computer technology has become integral to daily life," is being effected now as the marriage between Computers and Communications (C&C) becomes standard at a price that is within the reach of all.

But, as the saying goes, "we ain't seen nothing yet!"

Significant changes are occurring in the science and engineering behind telecommunications. Originally, all voice communication was done by analog transmission, sound waves transmitted in their original form. Traditional copper wire telephone and cable lines transmit data in wave form at about 30,000 bits per second. Fiber optic communications systems, which transmit data in the form of pulses of light, are capable of transmitting over 40 billion bits of data per second. That's equivalent to transmitting about a million pages of text a second (two thousand 500 page books per second!). And now the scientists have figured out a way of transmitting light at speeds faster than the speed of light! Yikes!

Why do we need to transmit data at such incredible speeds? Well, believe it or not, transmitting data electronically from one place to another is actually the bottleneck which slows down the work that computers do. If you have ever tried placing a telephone call on New Year's Eve, you'll know that it is possible for the telephone system to get overloaded even though the routing of calls is entirely computer-controlled.

Fiber optic and cellular technologies send and receive digital data, which you remember means bits and bytes. The development of analog to digital conversion devices means that more of our communication can be digital—which means more communications can be delivered at greater speeds, with little or no degradation of quality.

Communications companies and the manufacturers of communications hardware are continuing to design and implement data highways, transmitters and receivers that will be capable of high speed

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2 This will make better sense, perhaps, if you remember that the book and the ballpoint pen were also technologies that transformed education.

3 Fiber optics uses glass fiber tubes to carry pulses of light (lasers) from point to point. Each pulse of light represents one bit of data.
transmission of not only speech communication, but pictures and video as well. Currently, Internet communications based in Instant Messaging (IM) have made it possible for anyone with an inexpensive videocam\(^4\) to have "real-time" voice and video conversations with anyone who has a compatible system and connection. Five years ago it would have seemed futuristic to imagine video telephones, but they too are now a reality.

Websites, e-mail, games and movies can now be viewed on a cell phone; text messages are fighting with voice messages for popularity. Phones not only view pictures, they take them and transmit them. Wired and wireless Internet connections (free or low cost) can be used with a special telephone or microphone, eliminating the need for a standard telephone connection. Moreover, a \textit{symbiotic grid}\(^5\) in many metropolitan areas makes access to the Internet free to anyone with the right hardware. More yikes!

Alert schools can take advantage of these technology transfers. The remainder of this chapter will explore ways in which new technologies, coupled with old technologies, can be used to meet essential communications needs.

\textbf{Explosion in End-User Computing}

The Internet is proving to be the wedge, what some like to call the “killer app,” that is opening up an explosion of data communications capability. At the same time, we are witnessing an explosion in end-user computing. In the bad old days, prior to the 1980s, computer use was controlled by information systems (IS) personnel. But today, relatively non-technical individuals with a modicum of training, teachers included, are taking advantage of the availability and ease of use of desktop, laptop and handheld computers to exercise personal control over the processing of "their" data and the transmission of their communications. Thanks to the graphical user interface (GUI), teachers, students and parents can interact with a computer with a minimum of technical preparation, in much the same way that the modern automobile is relatively simple to drive. The challenge is no longer: How do I use this machine? The challenge now is: How do I use this machine to improve the effectiveness of what I do? For the teacher, this means teaching, learning, and communicating.

\textbf{The Expansion of C&C in Schools}

In the so-called developed countries of the world, where expense is less of an issue, communications technology is now pervasive in schools. It is relatively inexpensive compared to just a few years ago. Thus, hard on the heels of the spread of C&C in homes and businesses, schools are in the midst of an explosion of networked computing that will further transform education.

The concepts that led to computer-integrated manufacturing (CIM) have been applied in forward-looking school districts where computer-integrated education is well established. In these schools, computers and related technologies are integrated into the classroom-based curriculum. C&C systems enable the students, the parents, and the teachers to form an electronic triangle with the

\begin{itemize}
  \item \textbf{4} Video camera—the shorted form of the term is often applied to devices that are attached to, or included in, a laptop or desktop. It also, of course, also applies to handheld video movie cameras.
  \item \textbf{5} Wireless access points aligned to form a "bubble" in which wireless access to the Internet is freely available.
\end{itemize}
interests of the students at its heart. Networked computer systems are linking students with other students. On-line databases, including the growing wealth of information available over the Internet, are giving students, whether they are at home or at school, access to a wide variety of resources for learning.

Computers are providing teachers access to a centralized database of student data—biographical, medical, academic, and behavioral. This is the kind of data to which teachers have always been entitled in the interests of best serving their students. But for all practical purposes, this information has not been readily available to them until now. School districts are taking advantage of the similar explosion of home Internet connections to also make this data available to parents—and students—24/7.

Networked computers also are removing the concept of the closed classroom, opening up the students and teachers to the global community of their peers. For the time being, schools that have successfully integrated computer technology into day-to-day operations in and out of the classroom are still the exception in some areas; it will be some time yet before the school-teacher-parent triangle becomes truly and transparently digital. But the time is coming.

A measure of strength in schools is the extent to which all children, from the most gifted to those most in need, are given an equal opportunity to achieve. While money is not key to quality schooling, it is a factor, and there is currently too much disparity from one school district to another for true equality of educational opportunity to be guaranteed. To overcome this disparity, governments at local, state, and federal levels are teaming up with business and industry to help schools make the difficult transition to teaching and learning in a digital age—an age of information—and in the 21st Century—an age of information fluency.

Some states have passed so-called Robin Hood laws that call for higher taxes in the wealthier districts to help defray the costs for schools in areas where the tax base is low. Government also has decreed that communications companies must agree to produce educational programming and make it available free of charge to schools as a condition of gaining a Federal Communications Commission (FCC) license to do business. Further, we saw in Chapter 5 that the eRate initiative has promoted a significant upgrade of technological infrastructure (everything but hardware and software) in schools. Title I grants supplement state and local funding for educational materials, including software and Internet subscriptions, based upon the economic needs of the student population. Increasingly, industry and higher education are stepping forward to provide and promote communications partnerships with schools.

It remains up to the teachers and administrators to take advantage of these opportunities to promote the infusion of computer-based technologies in the schools. Those that do so will not be left behind in the 21st Century.

A Vision for the Future

"Ah, but a man's reach should exceed his grasp—or what's a heaven for." Robert Browning's words remind us that progress is something we humans strive after relentlessly. Progress does not

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6 The identification of 21st Century Information and Communications Technology Fluencies (or Literacies) is well under way. However, it will be the job of future teachers to both learn these skills and learn how to teach with them.
always bring beneficial effects, as the Arms Race sadly shows. But good progress is more likely to come about if we have a vision on which to focus our endeavors.

David Thornburg is founder and Director of Global Operations for the Thornburg Center and Senior Fellow of the Congressional Institute for the Future. Here is his vision for 21st century schools:

The 21st century classroom will be wherever the learner is located—a room at a school, on the bus ride home, in the park, or on the playground. Traditional tools (e.g., books, pens and paper,) will co-exist with the high-end tech tools of the telematic era that is still in its infancy…

If our schools are equipped with the modern technologies of information and communication, they can serve as resources not just to our children, but to the community at large. This expanded role of schools as community access centers also fits with the reality that we have entered an era where lifelong learning is a necessity, not a luxury…Schools where young and old can learn, places where ideas can be shared, leverage points for economic development—all these and more become possible when we re-envision schools as active wired community access points to the entire planet. (Thornburg 2000)

This vision is already beginning to take shape. All over the United States are pockets of progress—sometimes the outcome of a few individuals’ efforts, sometimes the outcome of a statewide mandate. It is time to examine more closely the technology involved, and how it can be used in schools.

**COMPUTER NETWORKS**

A computer network is comprised of a group of two or more computers connected electronically for the purpose of sending and receiving data. The following are the basic components of all computer networks.

**Computers**

The simplest of computers can be used to link users over local and wide area networks. The more powerful the computer, the more sophisticated the communications it can handle, but even older computers can act as serviceable "dumb" terminals to on-line databases, library card catalogs, e-mail systems, bulletin board systems (BBS), and the like. We will return to this idea shortly. Remember also that the definition of “computer” is changing as technology shrinks and the desire for portability increases.

**Communications Channels**

Shannon and Weaver (1949) formalized the terminology commonly used when describing communications systems. Fig. 7.1 (next page) illustrates the classic configuration of such a system, where a *sender* transmits a message over a *channel* or medium to a *receiver.*
As you can see, the communications channel, also called a 'medium', is what connects one communications device with another. Typical media used today for channels include cable- or wire-based media (such as copper wire or optical fiber), and wireless media such as radio waves (cellular phones use a type of radio wave\(^7\)). Advances in telecommunications technology are leading to faster and faster transmission speeds, or data rates, (measured in bits per second (bps)), making computer networks all the more viable for a multitude of applications both in and out of the classroom, such as those discussed later in this chapter.

The term bandwidth describes the difference between the highest and the lowest frequency in a channel. The greater the bandwidth, the more data can be sent in a given amount of time. The narrower the bandwidth, the lower the data rate. This translates to the speed at which the user can send and receive digital information. Think of bandwidth as though it were a pipe. A narrow pipe cannot channel fluid as fast as a wider pipe. Conversely, the wider the pipe, the faster the fluid can be poured along it. Electronic data, whether in the form of electro-magnetic waves or light waves, can be transmitted faster along broadband channels than along narrowband channels.

**Modems and Fax/Modems**

A modem is a simple device that connects computers to wide area networks, most often the telephone network. This is necessary because the telephone lines, for the most part, still transmit data in analog form. Remember that digital data is discrete, made up of separate electromagnetic pulses called bits (0 or 1). An analog signal is continuous, made up of electro-magnetic waves.

\(^7\) The FCC assigns specific frequency ranges to the various use groups. Your cell phone shares its frequency range with garage door openers and wild life tracking collars.
The modem converts the computer's discrete digital data into the wave or analog form necessary for transmission over the telephone system and vice versa.

The word modem is a contraction of modulator-demodulator. The modulator component of a modem converts the data from digital to analog form; the demodulator converts the data from analog to digital form. Both components are necessary for two-way communication between computers that are connected by an analog transmission medium. Fig. 7.2 illustrates this process.

In a dial-up network connection, the speed of communications is, for the most part, determined by the speed of the modem connected to your computer.

The majority of modems are capable of transmitting data no faster than about 64 Kbps (kilobits per second), that is, 64 thousand bits per second (modems today are generally listed as 96 Kbps, but cannot actually achieve this speed due to the capabilities of the telephone lines). The data may be traveling over the telephone lines at close to the speed of light, but when they reach the bottleneck which is your modem, the whole transmission process grinds to a painfully slow pace.

Telecommunications companies are involved in an ongoing project to replace traditional analog electro-magnetic media (copper wire telephone lines, for example) by much faster and more reliable digital fiber-optic cable. DSL modems (Digital Subscriber Lines) and cable modems (which use coaxial cable TV lines) are digital devices; they provide significantly faster Internet connections by making use of otherwise unused copper wires or of fiber optic cable. Many schools use cable modem connections; others lease T1 lines from a telecommunications provider.
DSL and T1 lines have a capacity of around 1.5 Mbps (1500 Kbps). Cable modems have a possible capacity of 10 Mbps, but actual speeds are much slower\(^8\).

The time is coming when "dial-up" modems will be obsolete—like typewriters—because there will be no need to convert data back and forth between analog and digital form. As wireless media are refined, and the “wireless grid” is expanded, wired network connections are also disappearing. For schools, as for the business and home user, this will bring about true portability of the "transmission/receiver" hardware—whether it be the computer or PDA or integrated cell phone.

**Other Communications Hardware and Software**

Telecommunications hardware for desktop computers takes the form of circuit boards or electronic components that are plugged into the logic board inside the computer. Like most of today's modern desktops, laptops often have a built-in analog modem. Additionally, connection to a wired or wireless network requires a NIC (Network Interface Card), which may be "integrated" (built-in) or a removable card about the size of a credit card\(^9\) (this is often the case for laptops and handheld devices).

You will run across the term *Ethernet* often. This refers to the cable that connects computers inside of a network, using the NIC (which has a plug similar to, but larger than, a telephone connector plug). There are currently four speeds of Ethernet: 10Base-T (10 Mbps), 100Base-T or Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps), and 10-Gigabit Ethernet (10,000 Mbps). The NIC card will determine the speed at which a computer will actually be able to send or receive data, no matter what the potential of the line. The line will determine how fast data moves between computers and inside of the school, no matter what the potential of the connection to the outside world (called "the backbone"). Needless to say, faster is better—and more expensive. It is not unusual for schools to have a mix of modems, 10Base-T and newer 100Base-T connections.

Wireless, *Wi-Fi*, connections use radio wave frequencies and require a "wireless card," which can be integrated, plugged into the motherboard, or a removable PC card, and an antenna (part of the card or, in the case of some laptops and handhelds, part of the hardware design). These connections today come in two speeds: 801.11b (11 Mbps) and 802.11g (54 Mbps). Actual connection speed will still depend upon the frequency available to the user and the distance from the wireless “access point”\(^10\). Teachers should know that a “wired” connection is always significantly faster than a wireless connection. For this reason, some schools maintain “hardwired” labs for purposes of standardized testing and videoconferencing.

Current operating systems have the software necessary for networking built in. Modems and NIC cards are generally "plug and play"—meaning that the necessary software is already on your computer. The operating system (Windows, Linux, or Macintosh OS) will "see" the device and load whatever is necessary to use it effectively. This means that it takes very little work for a user

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\(^8\) If you are using a modem, DSL, or cable modem connection, you can check its speed at Broadband Reports ([http://speedtest.dslreports.com](http://speedtest.dslreports.com))

\(^9\) These are referred to as PCMCIA or PC cards, or sometimes "ethernet cards"

\(^10\) An access point is a device that makes it possible for a wired network to talk to wireless access cards. Apple’s Airport is a common example in schools. One access point can connect to many computers.
to start connecting to a network. In order to connect to the Internet, or directly to other remote computers\textsuperscript{11}, you will need an "internet service provider"—an ISP. These are companies that provide access to the network that is the Internet. The cable companies and phone companies that provide schools and homes with modems are ISP’s, along with a myriad of local and national companies. The Internet is not "free" to schools or individuals (except for those \textit{symbiotic grids})—accessing it requires the payment of a fee.

A \textit{browser} (\texttt{Safari}, \texttt{Internet Explorer}, \texttt{Firefox}, for example) enables a computer or other device to "see" the content of a web page. Other software serves other purposes. An \textit{ftp} program makes it possible for one computer to connect directly to files on another computer—you actually "see" the section of another hard drive to which you have access permission\textsuperscript{12}. A \textit{mail program} enables you to retrieve, send and manage e-mail. The telecommunications hardware and software together take care of hook ups and the other protocols\textsuperscript{13} that maintain a trouble-free connection between one computer and another.

Some understanding of networks will be helpful for you, whether you are using a network at home or in school.

A computer network interface connects each computer to the communications channel (cable or wireless media) so that data transmission can take place. Every device (including printers, scanners, copy machines\textsuperscript{14}) on the network has a unique address, called an IP (Internet Protocol) address. Without this address, digital data, traveling in \textit{packets}, would not know where to go. Some devices on a network have \textit{static} (permanent) addresses (printers, access points, copy machines, servers, routers, hubs, modems). Most computers and laptops will have \textit{dynamic} IP addresses that are reassigned each time the computer is turned on. Some videoconferencing systems require that you find the IP address of the transmitting computer, but otherwise you don't need to know it, for each computer is also identified on the network by the "real name" of the user or the hard drive or the section of the web server, which could be a room name, a computer number, a URL (web address), or even your name.

Each network interface device also has a unique number, called a MAC (Media Access Control) address. This number is used to limit network use only to selected computers and devices. Even though you are not generally aware of it, when you use a networked computer, you can be clearly identified! You can also be blocked, which is why you need to know the vocabulary—so you can ask to be given access!

\textbf{Different Kinds of Computer Networks: LANs, WLANs, WANs and MANs}

Local Area Networks (LANs) connect computers over short distances—anywhere from a few feet to a kilometer or so. The simplest LAN is two computers connected by an Ethernet cable.

\textsuperscript{11} Many schools originally connected computers "peer-to-peer," or directly to each other in a sort of daisy chain, to form a network in a lab. This is still a sound way to transmit large files quickly. It is discussed in the next section.

\textsuperscript{12} Some schools have "invisible ftp" to enable teachers to post to web sites. Apple’s .iDisks are also .ftp enabled.

\textsuperscript{13} Protocols are the rules of the road in communications systems, such as transmission speed and connection conventions (called \textit{handshaking}).

\textsuperscript{14} It is not necessary for these devices to be on a network. Often, they are connected directly to a computer. In this case, the network can be used to "share" access to the host computer, and thus to the printer or scanner.
This direct connection of two computers, even if accomplished over the Internet, is called a peer-to-peer (P2P) connection. Schools use P2P networks to share data and printers in basic computer labs and in offices.

Today, most LANs include one or more high-speed computers called servers which have large memories for storing and sharing networked software, data, and resources needed by all users (such as printer drivers, e-mail systems, databases and websites). Servers are generally accessible to all users on the network, but access privileges will vary depending upon the identity and role of the user (teachers will have different access privileges than students and administrators). Creating this system of privileges is an important job of the IT (Information Technology) staff.

Two or more LANs of the same type (say in different parts of a school or school district) can be connected using a hardware device called a bridge. School networks also often make use of hub, which interconnects all of the networked devices and connects directly to the "backbone," or use several hubs to form mini-LANs. A switch is a hub that detects the protocol of the data packets that flow through it and directs it to the correct device or port (think of it as a route) on the network. A router (sometimes called a gateway) is a device used to connect LANs of incompatible types (i.e. they use different communications protocols), most often to connect a school LAN to the Internet or to connect an older wired network to a newer wired network. This is pretty technical stuff, but you might like to know that most networks now use TCP/IP protocol.

Fig. 7.3 illustrates a typical LAN configuration in a school making the transition from wired to wireless. It might also illustrate the LAN in your students’ homes.
A wireless network, or WLAN, also contains *access points* (or base stations), devices that connect a wired LAN to one or more wireless devices. All of the devices above can be wireless as well as wired, but it is important to remember that all wireless networks at some point connect to cable!

An important piece of any LAN is the *firewall*, which may be hardware or software or both. As its name suggests, the purpose of the firewall is to secure a network by preventing unrestricted access by an outside user. Imagine the damage that could be done if an angry student decided to rewrite grade reports! When the firewall is "down" a network can be "hacked into."

Bluetooth is a new shortwave technology that uses radio waves to create a wireless LAN within a classroom, office (or home). Devices equipped with Bluetooth chips can speak to each other (voice and other digital data) no matter what their protocol. PDAs, computers, mobile phones, and various handheld controllers (like joysticks and adaptive devices) can be networked in this way. One use of Bluetooth is the remote control of a teacher’s laptop when it is projected on a whiteboard. A Bluetooth-enabled pen can act exactly like a touchpad and cursor! This is technology finding its way into today’s classrooms.

Lastly, *infrared* provides a simple network when used with some laptops, PDAs and infrared-enabled printers. Students can use infrared to "beam" data to another device or to a printer, without the need for wires or wireless access points. This technology is limited to short distances and a clear "line of sight."

“Artificial” networks for data transfer are also possible. The inexpensive device called a *key drive* or *USB flash drive* is portable memory. By plugging it into the USB port of one computer and then another (forever…), data can be quickly and inexpensively shared. Similar results can be obtained by using a CD ROM on which data has been stored. Teachers often find that these two devices are quicker and more convenient than sharing data over a network, especially large data files such as presentations, video and image libraries.

A Wide Area Network (WAN) establishes communications paths between computers that are scattered over areas that span anywhere from a kilometer to the area covered by the accessible universe (space stations, shuttles, and space probes have on-board computers for communications). Fig. 7.4 (next page) illustrates this concept. The Internet is a WAN. In addition to the devices we have already mentioned, a WANs now includes cellular devices that connect with Internet chips. This is a much slower connection than either wired or wireless (about 800 Kbps), but it is truly communication any time, anywhere.

A Metropolitan Area Network (MAN) is simply a smaller (city-based) example of a WAN. Fiber optic cables are being used to create MANs in large metropolitan areas where the underground infrastructure (subway systems) makes it easy to run the cable. These networks are the fastest, for the cable is necessary for 10-gigabit Ethernet. Wireless MANs are also being developed in urban areas—these are the *symbiotic grids* we mentioned earlier.
Schools are exploring the uses of LANs and WANs for teaching and learning. Innovative communications applications are providing students with exciting collaborative and cross-cultural experiences. Of special interest are the wireless network options described that, because of technology advances, are becoming mainstream in schools. It can be safely predicted that, not too far down the road, ALL students and their teachers will each have a personal wireless portable computer (probably hand held like a cellular phone) that will be able to access all available online services anytime anywhere. This reality eventually and inevitably will transform the way education is done.

APPLICATIONS OF COMPUTER NETWORKS

Computer networks are commonly used for two kinds of operations: communications and the sharing of hardware and software. As you have seen, with the development of more powerful computer processors and the proliferation of cellular, microwave\(^\text{15}\) and fiber-optic media,

\(^\text{15}\) Cellular phones use microwaves, which are high-frequency radio waves, beaming a system from "cell" to cell. Other wireless signals, such as those used to connect buildings wirelessly, are "point to point."
networks are becoming more powerful—capable of handling larger volumes of data at higher speeds. As a result, using them frequently and integrally has becomes more viable for teachers and schools.

*Telecommunications*

This involves the transmission of data (text, still images, video, and audio) over short and long distances. Examples are:

**Electronic mail (e-mail)** For the most part, e-mail is used to exchange information between two or more individuals using computers. E-mail is essentially asynchronous, which you remember means that messages are read at some point in time after they have been sent. A *listserv* is a message system for a group of users who subscribe (generally for free) to receive e-mail messages sent by other members of the group. This is a wonderful way for teachers to stay up-to-date, to network, and to share concerns and successes. Listserves are gradually being replaced by *email subscription*, used commercially as well as educationally. Generally, users sign up for the subscription by adding an email address to a web form. Subscription messages are informational and generally 1-way. Many educational newsletters are now distributed this way. Most e-mail systems support the use of *attachments*, which are digital files literally connected to the message and downloaded when the message is opened. Webpage (HTML), audio and video mail (asynchronous transmission of digital video) are becoming more common due to the increases in upload and download speeds and to the greater memory and processing capacities of user computers. It is also now easy to use a cell phone to text a message to an e-mail account. As you can image, however, e-mail can be a huge bottleneck on a school network. Other ongoing problems with e-mail are *spam* (unsolicited "junk" e-mail that is often offensive in nature) and e-mail’s propensity to spread computer *viruses* (often to the surprise of the sender). A good school network blocks spam and has virus detection and repair software installed on all computers. Make sure you have virus protection software such as Norton *Antivirus* installed on your computer, too.

**Bulletin Board Systems (BBS) and Forums** These are text-based system for sharing information stored on a central host server. Users access the system to share ideas, software, and data with other users. Most often, bulletin boards, or *forums*, are used to expand upon discussion topics. The resulting *threads* can be read from beginning to end, even though they were created by many writers over a long period of time. Some e-mail applications, notably *First Class*, make it possible for teachers to form *Conferences*, allowing them to share ideas and information within the school network. A *tag board* is a mini-bulletin board that can be added to a personal web page. It operates more like an old-fashioned message board: users add their messages to a continuous stream of posts.

**Voice messaging** Voice messaging is similar to e-mail in that it is asynchronous, but the medium of communication is voice rather than simple text. Users do not interact in real time; in other words they cannot respond in real time as on the telephone. The voice message is stored temporarily in an electronic "mail box," like e-mail. Schools use a computer system to manage voice mail, but to the teacher it appears like a home telephone.

**File exchange** This is the same concept as e-mail except that formal computer files, rather than informal mail, are transmitted from one computer to another. Exchange can be via attachments,
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P2P connections (examples of this are the infamous Napster application for sharing music files directly off of a home computer), on a network or internet server (commonly found in schools), or through web-based file posting. The availability of "universal" file formats such as .rtf, .pdf, .jpg, .gif, .html, .swf and .mov make it possible for users to exchange files regardless of the computer platform on which they work. Types of files that can be exchanged for educational communication purposes are video files—a filmed lesson, presentation, or speech—and worksheets.

**Local and remote on-line data retrieval** This is the Internet, generally the World Wide Web. The Internet is, in a sense, a huge database, each web page, news group topic, stored file or e-mail message being a record in the database. Accessing, adding to and making sense of this database is becoming central to education.

**Real time, interactive voice, and data interchange** The computer can be used for interactive two-way communication. The simplest of these communications are through chat and IM, both of which often contain voice and video modes (see video conferencing below). It is now possible for many users to "share" a networked document or file, editing it in real time. The ability to create interactive databases, with real-time charting and graphing, has enabled webmasters and universities to make the exchange and analysis of numerical and text data a synchronous event (this has always been possible over a handheld, infrared network). Similarly, "realtime" whiteboards (like paint applications, complete with tools for drawing and typing) make it possible to remotely discuss and brainstorm in realtime.

**Video conferencing** Perhaps most exciting for children, video conferencing allows users to communicate over live video and voice communications systems from remote locations. People can "meet" electronically in real time, thus saving the time and expense of traveling to a central location. As previously discussed, inexpensive hardware and free software are making video conferencing much more available to the classroom teacher.

**Social networking** Can all of these modalities work together? You bet – and most students are doing so every day, whether the teacher likes it or not. Social networking refers to Internet spaces that make it possible for “members” (membership is generally free) to quickly and easily share any type of digital information, to communicate in real and asynchronous time, to gather a list of “friends” with whom all forms of communication are almost seamless. Teachers can use a site such as Classroom 2.0 to network with like-minded educators. Students (and teachers too) are active in Facebook, YouTube and similar sites. Working professionals have accounts with Linkedin and Xing16. Social networking is now also specialized; many teachers use services like Bloglines to share interesting blogs or Del.icio.us to share

**Hardware Device and Software Sharing**

Networks enable users to benefit from sharing expensive, high-speed, high-quality, centrally-maintained devices such as printers, digital copiers, specialized cameras and microscopes—even telescopes and robot arms. Users also can share large capacity storage devices such as file servers for the mass storage of data and high-speed processors for data analysis. Finally, for special

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purpose applications, users can share processors (discussed later in the context of dumb terminals). This sharing of networked hardware and software creates a powerful learning environment.

Network versions of software, accessed from a central file server, offer several advantages over single (or local) software installations. First, they are usually a cost saving because a site license is less expensive than buying software one copy at a time. Second, since use of the networked versions is managed by a server, the school or institution is protected against software corruption, piracy and licensing violations. The school is able to log, or track, the use of its investment. Networked software also ensures that all users will have access to the same suite of applications. As changes are made to software and upgrades released by software developers, new versions that are centrally controlled can easily and consistently be made available to everyone in the school or school district.

**The Case for Computer Networks**

"Computers should be used to tie people together, not to separate them." This is the conclusion of Selfe (1992), who goes on to recommend computer networks to "help create communities among groups of students" where they can "share their writing electronically, conference with teachers via electronic mailboxes, and practice argumentation and written dialogue skills on electronic bulletin boards."

Selfe's vision for the teaching and learning of the English language is being realized across the broader academic curriculum by the growth of Internet access in schools. This is resulting in a greatly increased use of e-mail, chat and social networking among students, who are thus writing more than ever before. This being the case, communications technologies should have a significantly beneficial effect on the ability of children to learn.

But computer networks in schools have more applications than simply improving communications skills. Selfe references Fersko-Weiss (1985) when he observes that "networks can expand students' perceptual boundaries, allowing them to tap into rich sources of library data and bibliographic information and become acquainted with the thinking of individuals from other countries or cultures." It is this global communication skill that is one of the core literacies identified for the 21st Century school.

Currid (1992) makes a compelling case for networked computing when she reminds us of the kind of anachronistic bureaucracy that still pertains in many professional environments today. She describes the traditional "16-step procedure" for transmitting a paper-based piece of information from one person to another within the same organization (say, from the principal to a teacher).

The principal handwrites or dictates the memo and gives it to a secretary, who proofreads it and corrects it before either typing it or getting someone else to do it. Once the memo has been typed up, the secretary checks it over again before passing it back to the principal.

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17 Interestingly, students do not consider these activities to be “writing for school,” even when they are writing in school.

18 A list of 21st Century literacies can be found at http://www.noodletools.com/debbie/literacies/.
so she can check it over, too. Eventually it finds its way into the interoffice mail system and gets delivered.

Elapsed time: up to several days.

Alternatively, Currid observes, using networked computing, the same transaction goes like this:

Step 1: [Principal] drafts own document in a word processing program or the e-mail software.
Step 2: [Principal] sends electronic document to [teacher] and files a draft copy.
Step 3: [Teacher] gets message.

Elapsed time: 3 minutes to an hour.

The goal of every school district should be to put a computer on every teacher's desk (or in every teacher's hands in the form of a portable computer or networked handheld device) and to make a computer accessible to any student who needs it at any time. These computers should be connected to the rest of the world and supported by the media technologies, peripheral hardware and memberships that make collaboration and communication happen. If every teacher has a personal networked computer, and if every student has access to one, too, there is the potential for change in education equal to that produced by the printing press.

David Thornburg's vision of the future for education is closer to realization than most people are aware.

Implementing Computer Networks

The worst case scenario: putting obsolescent technology to work Many school districts have invested in computer technology which rapidly becomes obsolete. During the 1990s, millions of computer systems of all shapes and sizes were purchased for use in schools. Many of these systems are now considered obsolete because they are not powerful enough to run much of the new software, they are limited to operating systems that are no longer supported by software developers, they lack CD or DVD drives (and thus cannot even access software installers), or because they can no longer even access the Internet. There is no greater frustration for the student and the teacher than this scenario.

Recycling to the rescue! Just about any computer can become a dumb terminal on a network. Whether the computers are older Apple Macintosches or PCs, as long as they have hard drives and some expansion capability, many older computers can be used for the purpose of simple e-mail. Older office machines are often sufficiently powerful to serve as e-mail servers.

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19 It has been estimated that this totaled over $70 billion!
20 You may recall that there are two types of network terminals: dumb terminals and smart terminals. A dumb terminal is one that does not have its own processor and therefore cannot perform as a stand-alone computer. A smart terminal is a general purpose computer with its own microprocessor which can also act as a node on a network.
It would, of course, still cost money to purchase basic networking software and hardware components\(^{21}\) and to set up and maintain the network, but it would be money well spent in view of the extended lifespan given to what might otherwise be underutilized, antiquated systems. The amount of money would be a fraction of the cost of setting up every teacher and administrator with a new computer system.

Implementation of this idea would not preclude the necessity of purchasing up-to-date systems in the long run, because teachers will eventually want to use their computers for tasks other than e-mail. But as DeBalko (1992) observes, "e-mail alone, if used properly, can justify the cost of a LAN."

Thin-client technology provides another use of otherwise obsolete desktop computers. In this system, the local computer has only a "light" version of an operating system (a special system designed for this purpose), enabling it to connect to an application server that actually does the processing. The monitor displays activity that is taking place on the server, but the client user controls it. Thin-client solutions are highly cost-effective and can be used over a LAN or a WAN.

Some would argue that it is a waste of computing power to relegate a PC to the functionality of a dumb terminal, but this is better than not using the computer at all. Millions of computers are being discarded every day. Fortunately, there is an emerging recycling industry dedicated to repairing and reconfiguring such discarded systems so that they can be donated to grateful schools and charitable organizations.

A best-case scenario: Using current technology Money spent today on computer-based technology will buy considerably more than the same money spent during the early 1990s. This is because the computer industry is one of those rare industries where prices decrease even as the quality increases. For example, the price of secondary storage drives has fallen from about $10 per megabyte in the mid-1990s to a few cents per megabyte today. But not only has the price fallen dramatically; the drives are also much smaller (they can be put on your keychain), more reliable, data access is considerably faster, and the drives come pre-formatted and ready to go, with all the necessary disk management software on board.

This trend towards dramatic increases in value for money is likely to continue into the foreseeable future. Of course, the mere installation of computer networks will not transform the educational process. Teachers still must be trained and provided with on-going support—which must include time to integrate the technology into the curriculum. Nonetheless, it is useful to mention here Metcalfe's Law, first stated by Robert Metcalfe, inventor of Ethernet: The usefulness of a network equals the square of the number of users.

In other words: More access = More users = More demand for improved access—a never-ending cycle of demand if ever there was one!

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\(^{21}\) It should be noted here that a corollary to the speed of change is the speed with which old components disappear—necessary upgrades and software may not be readily available.
RECOMMENDATIONS FOR SUCCESSFUL INTRODUCTION OF COMPUTER NETWORKS IN SCHOOLS

There will be times when the funding is available and a school has the opportunity to build a quality network. To achieve this goal, a school must seek expert technical advice and probably a consultant. That said, we can also make these suggestions, which are rooted in the content of this text:

**Make a plan**—even if the implementation of the network is delayed, planning is the key to success in networking;

**Include the entire school community in the planning**—administrators, teachers, students, parents, alumnae, staff and the community at large—these are the people who will benefit from the network of the 21st Century school;

**Be visionary**—look as far into the future as possible when selecting protocols, systems and capabilities—remember Metcalfe!

Here are some other important recommendations:

**All computers and production devices should be networked together** The people that control the purse strings in schools should understand that it is a wasted opportunity when a computer stands alone, or when a printer serves only a small population, or when a video editing computer cannot save to a server, or when a kindergarten computer cannot speak to the fifth grade classroom. Even handheld devices (PDA's and calculators) should be viewed as potential network devices and, if necessary, outfitted for increased communication.

**Every classroom should be wired for Internet communications** In the next section of this chapter (Home-School Communications), and again in chapter 8, we will discuss valuable C&C applications as they apply to education and which become possible when classrooms are wired for Internet access.

**Schools should take advantage of Cable in the Classroom (CIC)** This is a free service provided by local cable operators and national cable programmers that makes commercial-free, copyright-cleared programming available to schools for use in the classroom. Schools which agree to use this service are wired for cable free of charge. In some locations, free cable modem service is also provided. Additional CIC materials include informational and news podcasts, lesson plans, and media literacy information. Access CIC at [http://www.ciconline.org](http://www.ciconline.org).

**Teachers should have access to systems that will encourage them to use the computer as a tool** These would include software tools such as the full range of productivity software discussed in Chapter 6; centralized on-line databases of student records; on-line school-wide calendars and announcements; networked support for curriculum planning; development and assessment; voice messaging for establishing and maintaining close contact with the students' families; e-mail systems; and support for creating their own web pages. Needless to say, it also means computers and other tools to access and use systems.
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**Teachers should have ready access to the voice messaging system** It does little good to have a complex voice messaging system if teachers cannot get to a free telephone, and access their messages, during the school day.

**Teachers should be expected to and trained to use the systems available to them** Many school districts may hesitate to implement these recommendations because they are strapped for money. But money need not necessarily be a prohibiting factor, since billions of dollars every year are made available, by foundations and government agencies, to support technological innovation in education. Furthermore, free opportunities for schools to create many of these systems are made available by foundations and civic minded industries.

Of greater concern than money is the training and support that is necessary once all the teachers and classrooms are on-line.

The next section will examine what some schools are already achieving along the lines of educational C&C thanks to the support that they have received at the local, state and national levels.

### THE IMPACT OF COMPUTER NETWORKS IN EDUCATION

The implementation of networking technology opens up the possibility of not only linking students and teachers within a school, but also linking a school to other schools, at all levels of the academic spectrum and all over the globe. Below are just four examples of the hundreds of ways in which schools are using computer and communications networks.

- Elementary-school students from five countries join in a virtual Learning Circle to share their knowledge and understanding of their community, history, government, and culture.
- PreK-5th grade students in Miami Country Day School are lucky to have the Abess Center for Environmental Studies (http://aces.miamicountryday.org) on their campus. Using its network resources, share their learning with students and scientists around the world.
- Middle and High School students worldwide undertake a historical and photographic study of the houses, buildings and monuments in their towns. Images, reflections and learning are shared on the project website.
- K-12 students around the world collect and analyze environmental data, using portable devices, and enter it into an interactive database. Their research and results are shared with active scientists as well as other students worldwide.

The benefits of networked computing in projects such as these are compelling. As time goes on electronic communication will replace much traditionally paper-borne interaction between teachers and administration, between one teacher and other teachers, between teachers and students, between students and students, between teachers and parents, and so on. But change will be slow, since it is not only a question of buying the equipment, installing it, and maintaining it on an on-going basis. Teachers and administrators must also change the way they think about education. "There's the rub," for that change inevitably involves both physical and cultural
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adjustments at the individual and group levels. One group than can benefit immediately and markedly from 21st Century change is parents.

HOME-SCHOOL COMMUNICATIONS

Schools Need Parents

One of the greatest weaknesses of education, in modern times at least, has been the distancing of the home from the school. There has come about an almost complete dichotomy between what goes on at home and what goes on in school. The result is the loss of an opportunity to develop an essential partnership. The National PTA National Standards for Parent/Family Involvement Programs sets as standard #1 communication between home and school. The school's best ally in the task of nurturing a student's innate "urge to learn" is, first and foremost, the parents. A Nation at Risk (1984) paints a sobering picture when the report states that while parents do have "an undiminished concern for the well-being of their children," for the most part they are not culturally encouraged by the education system to intervene in their children's education. Unfortunately, this distancing has not improved in the last 25 years. Working parents, language differences, economic and cultural divisions, and a history of schools regarding parents as intruders and critics rather than partners have are built walls. Schools too often pay little more than lip service to the idea of involving parents in their children's education and parents have not, until recently, been active in seeking involvement.22

Eliminating this divide is one of the mandates of the NCLB legislation, which you will remember is also actively seeking to guarantee the education of all children, at all economic and academic levels, and speaking all languages. The government of the United States, then, recognizes that schools need parents.

The best schools educate the parents (and the community) as well, not in a patronizing way but out of a passion for the students' intellectual and personal welfare. The best schools listen to the parents and make them a part of their child's education. Returning to Thornburg's vision of the 21st Century School as a "common meeting ground," parent education and involvement are crucial elements in the future of education.

Parents Need Help, Too!

Now that a public school's "Report Card" is public information, parents have a chance to evaluate the educational outcomes of their school, or at least the results of standardized assessments. If parents are troubled about their child's education, what should they do? They should turn to the school. If they get the feeling that they are not welcome or that the school doesn't have an answer to whatever the problem might be, should they not seek a second opinion? Should they not take their child elsewhere? Maybe they should, and the NCLB allows them to do so without penalty after two years. But they don't really have a lot of options—other than very expensive ones. Few parents can afford to move to another school district, pay for transportation to another school, or

22 Consistently, research has shown that fewer than 50% of parents visit the school during the school year.
seek out a private education for their child. It is for this reason that the NCLB has mandated that schools seek or create better communication channels.

This is necessary for all parents, but perhaps most true for parents of children with special needs. When it comes down to it, if parents of children with special needs are not an integral part of school life it is the larger society in general, and the schools in particular, that are to blame. The parents have no choice but to rely on the school's willingness to include them and educate them. All too often the parents are powerless because they simply don't know what to do and are left out in the cold.

Susan Isaacson is a special education teacher in Fairbanks, Alaska, certified to teach K-12 in special education with endorsements in the areas of the Learning Disabled (LD) and the Emotionally Disturbed. Susan has this to say about the need for schools to work with parents when children fail to achieve at the level of their abilities:

If you have low achieving students who are definitely very capable, what is the primary problem? If we say that there is some type of traumatic situation that occurred, or that there is evidence of ADHD, then why do I not have my classroom overflowing with more students? For heaven's sake, there are many students who have incurred some type of extreme emotional trauma, but who do not require special education. There are also many who are very "busy" kids with attention problems, but who are not found to need special education. Why? It's easy. Most all of the children who end up in my classroom come from homes which are far from the ideal.

Many [of the children] have been in one foster home after another. Some have not been removed from the home, but should be! If these children had been given a nurturing environment when they needed it, most likely they would not have fallen so far behind in their academics nor would they have begun to act out behaviorally. That's why I don't have half the school in my little classroom, because there are those good families out there and there are people who sell everything they have to get their child the help they need.

I truly believe that half of my parents are in need of a good evaluation because they have never had their special needs (be they medical or psychological) addressed. So they are limping along, doing the best they can, not realizing they are many times adding to the problems with their own children.

What may be part of the solution? I believe that if we are to continue to offer students special education, then we need to place a requirement on the parents/guardians. That requirement would be a simple parenting class, which could be listed as some type of special education course to support parents. This course could involve touching on subjects such as ADHD, along with the most current information, including pharmaceutical intervention/alternative medicine (and there is a place for both!). This course could involve such topics as mood swings and depression, which many fail to recognize in children. This course also could involve instruction in the necessary organization of home life when it comes to homework and preparation for a good school day (including preparing nutritious food on a shoestring budget).
The course should be a mandatory requirement or no special education: how about it? I think we would see a lot of eyes opened. It has to be made clear that the only way to success for children is support from home, and that school and home must work hand-in-hand. We must empower our parents. But we must help them, too. Society must be willing to bear the cost of helping families with special needs. It’s a matter of educating the leaders of our country so that we can get the funding to educate families such as these.

The Schools Must Take Responsibility

The responsibility for changing this state of affairs must lie with the schools. The parents are on the outside looking in. Culturally—traditionally—they are not supposed to interfere with what goes on in schools, and when they do they are regarded (respectfully, of course) like students with behavior problems, even when they are only trying to get help.

In their summary of the literature, Marshall and Rossett find that "the strongest predictor of academic achievement is the family’s ability to create an encouraging home environment, to express high but realistic expectations for achievement and the future, and to become involved in their child's education." (Marshall 1997). Surely this is good for all parties involved—student, parent and teacher.

The importance of the Student-Parent-Teacher Gestalt

Wertheimer, the father of Gestalt psychology, argued that an organized whole is greater than the sum of its parts (Bigge, 1992). "For example," Wertheimer observed, "a triangle is greater than the sum of the three line segments that form it. This is because of its Gestalt." The triangle is an appropriate analogy for the argument we are trying to make, for it is the triangular relationship formed by the parents, the teacher/school, and the child that is greater than the sum of the three entities taken separately (Fig. 7.5).

Fig. 7.5 The student-parent-teacher Gestalt
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You may have good parents, a good teacher, and a good child, but if they do not work together, the strength that could be derived from the Gestalt is lost. This perhaps explains why so many children, academically able or not, simply do not enjoy being at school, no matter how much "fun" they may be having, because they do not consider school to be integrated with the rest of their lives.

It seems reasonable to conclude that the more schools do to meld the triangular Gestalt formed by the child, the parent(s), and the teacher, the more committed the child will remain through the long process of formal education. And "if time and opportunity to communicate are the barriers [to making the Gestalt a reality], then telecommunications technology can come to the rescue" (Bauch, 1990).

The TransParent School Model

The original TransParent School Model, developed and formalized by Jerold Bauch at the Betty Phillips Center for Parenthood Education at Vanderbilt University, uses telecommunications technology to provide "voice-based information exchange between teachers and parents." The model, described in The Parent Involvement REPORT (1992a), is purposely simple, both technologically and methodologically, so as to make it as easy as possible to implement.

The components of the model are as follows:

- **Network infrastructure**: computer-based voice messaging system is installed at the school site.
- **Current information**: each day the teachers prepare a brief script, describing
  1. what their students learned during the day;
  2. specific homework/home learning assignments;
  3. parent education suggestions;
  4. any other school information.
- **Teacher-parent contact**: the teacher records the message in a voice mailbox. Some schools wire classrooms with phone jacks, others locate phones in faculty areas. Parents can use home or work or public phones to leave messages for teachers.
- **Anytime retrieval**: all parents can call and hear the message at any time.
- **School-wide information**: there are other voice mailboxes on the system, accessed with different phone numbers, which can contain messages about such items as the daily lunch menu, sports or performance event schedules, and so forth.

Outcomes of the TransParent School Model

The TransParent School Model has had several interesting outcomes, especially for those families where the parents have taken most advantage of the system.

- These parents are now more involved with their child's education.
- They notice that their child completes more homework assignments.
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- They see an improvement in their child's skills.
- They observe an improvement in their child's grades.
- They feel better about the school.

_C&C Today - Extensions of the TransParent School Model_

New technologies and the faster networks that have been described in this chapter provide the school with new strategies for communicating with and involving parents. Here is a run-down of what is now possible:

- **E-mail**: Most schools make teacher and school e-mail addresses available to parents and encourage their use for day-to-day communication. Although certainly not all parents have access to an e-mail account, e-mail is the most common use of the Internet by adults today. Many schools give parents the choice of receiving announcements in print – e-mail is the default; parents can even sign up for accounts on the district e-mail server.

- **School websites**: 98% of the schools in the US now have websites. These serve many uses, but communication is perhaps the most important. In-house and externally housed sites can now be easily created with the equivalent of "digital templates" and secure digital databases—making it possible for teachers to post assignments and lesson plans, for schools to make student reports (grades, attendance, behavior) available online to parents, and for all announcements and other school information to be available "24/7." A good site will contain a "feedback form" to encourage parent response.

- **Other digital communication**: Parent bulletin boards and blogs can easily be implemented once a school has a website or has connected to a "school content provider." These also can be used to provide homework help. Some schools are exploring the use of video conferencing and "streamed" (stored for viewing at home) videos to promote parent understanding and involvement in student learning. The web-based publishing of classroom notes, facilitated by applications such as Aquamind’s _NoteShare_, make streamline communication about daily content. Many teachers are also using free blogging tools, such as _Edublogs.org_, to post class summaries, notes, and assignments.

**The Importance of Choice**

Choice is important, for although we would like to put it behind us, the _Digital Divide_ still exists. Not all parents have home access to computers or to the Internet. We techies tend to forget that print is also a technology, one that reliably reaches the largest number of parents. For this reason, the best implementation of a _New_ TransParent School Model includes parent choice and school follow-through that embraces:

- **voice messaging** in all of the languages (Spanish, Vietnamese, Arabic, Urdu, etc., as well as English) spoken in the community of parents;

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23 These are generally commercial concerns that host school web-based content, deliver lessons, and provide interaction and communication tools for subscribed members of the community.
Chapter 7: Computers and Communications (C&C)

- *person-to-person (face-to-face) communication*, especially *home visits*—this is "foot" technology, and, although beyond the scope of this book, has been proven to be highly successful;
- *print/mail options*—these include "backpacking" and postal mail and should also be multilingual;
- *digital telecommunications*.

It is most important that a school reach 100% of its parent community and that 100% of the parents respond in some way—daily would be ideal.

**LOOKING BACK**

Naisbitt (1982) describes his high tech/high touch formula as the balancing act between the introduction of new technology and "a counterbalancing human response." Naisbitt's intent is to show that the counterbalancing human response (the high touch) is often a reaction against increased implementation of new technology (high tech). But this is not necessarily the case. Often, a heightened human response is a *complement* to new technology. This especially can be true of C&C in schools. By putting parents, teachers, and students in touch with each other and with the local and global community, high tech C&C is extending the reach of education to the high touch benefit of all.

In this chapter, we have examined the impact of C&C in education, and the conclusion is inescapable that this technology is becoming an integral part of both educational administration and of the learning process itself. Today, at the beginning of the third millennium, close to 99% of personal computers are used for communications such as e-mail and Internet access. While this figure pertains to across the board PC use, schools, too, are experiencing the same evolution. As the new, connected systems are set up alongside the old, it has become necessary to integrate the older computers with the networked machines for the purposes of file sharing, communications, integrated learning, and so forth.

As Schmall (1992) pointed out, institutions that increase the quality of services such as networking "should not lose sight of what [these improved services] cause in terms of user's rising expectations." Once people get a taste for easy and well nigh instant access to others in particular and to on-line services in general, they will quickly reach the point where they will be unable to do without such services.

The strains put on computer networks to meet these rising expectations can easily result in performance degradation when the system is pushed to its limits. This is a sufficiently common phenomenon for networks to have been have been facetiously nicknamed "notworks!" However, if the most common problems associated with networked computer systems arise from overuse, is this not compelling justification for their implementation in schools? Remember Metcalfe!

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24 You know by now that "instant" or immediate communication is synchronous, but most of the communications solutions we have discussed are asynchronous. This means, in practice, that though parents may expect an immediate response—they may have to wait for a teacher to have a free moment!
LOOKING FORWARD

In the next chapter, we will examine the subject of computers and communications as the medium for distance learning and as the backbone of the Internet.

A key ingredient of our successful adaptation to an Information Age is our ability to access, process, transmit, and receive data to serve our information needs. Internet access is already ubiquitous in so-called developed countries in general and is rapidly becoming so in particular in schools. The information available on the ‘Net is growing by leaps and bounds. On-line resources made available for teachers and students K-12 are already extensive, and growing day-by-day. The Internet thus warrants special attention, since it is a medium that is transforming education.

Along with the Internet, we should examine the concept of distance learning. As networked environments become the norm both in schools and at home, students will have opportunities to interact on-line with other students and with globally-located learning resources. More and more learning will take place in virtual learning environments where information in digital format will be discovered, accessed, processed and shared.
Chapter 8

E-Learning and Information Literacy

I think we have a data overload and yet we have very few people who are actually able
to use information successfully.

*John Sculley (1939 - ), past CEO of Apple Computer*

When thou enter a city, abide by its customs.

*The Talmud*

The breakthrough opportunity is to increase learning through transformations in the social
participation of learners in different communities for knowledge building.

*Roy D. Pea et al*

**LEARNING OUTCOMES**

The Internet may be the best thing since sliced bread. It certainly is the most significant agent of
educational change since the printing press and movable type\(^1\). Because of it, education at all
levels K through college is undergoing a transformation that is affecting how teachers teach and
how children learn. The Internet is everywhere, reaching into every nook and cranny of our
world. As we saw in Chapter 7, telecommunications companies worldwide are racing to develop
systems capable of coping with the rapidly increasing demand for Internet-based
communications services, which will give people well nigh instant access to the data they need
to help them plan—and enjoy—their lives.

Integration of the Internet (and soon Internet 2) into the everyday process of teaching and
learning is happening, but not at the speed of technological change. "Powerful ideas," Kay
(1994) observed, "create needs only they can fill. This is the essence of paradigm shifting
[which], as Kuhn noted, takes longer than one would think or hope."

So much has to happen first, and it’s not just a question of the technology. Schools have to
prepare teachers to use the technology and to incorporate it into their curricula. Many schools
still have to invest in, and install, not just computers, but a sufficient number of networked,
Internet-ready computers to make their instructional use feasible. Many schools still have to be
wired for high speed, ideally fiber-optic, access to the Internet.

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\(^1\) Although the Chinese also invented a printing press, the press invented by Johann Gutenberg in c1450 is the
focal event in the Western world.
Chapter 8: E-Learning and Information Literacy

Today's teachers-in-training need to be ready for the paradigm shift\(^2\) that is coming to education. If the last two decades were the Age of Information, the early 21st Century is the Age of Information Fluency; using the Internet and other network resources effectively to develop learning and learning skills is an essential component of the toolkit of today's teachers. Included in this new fluency (or literacy) are problem-solving, communication and collaboration skills, as well as the 3 R's. It is inevitable that schools will turn to e-Learning for the development of 21st Century Fluency skills. Hence this chapter in our book.

In the pages that follow you will first be asked to reflect upon the learning process in general, and then to apply learning theory to teaching with new technologies. You will examine the concept of e-Learning in general, and of distance learning, videoconferencing and collaborative projects in particular. We will end with a look at Information Literacy skills and address some of the educational concerns that inevitably accompany use of the Internet in the classroom.

- Reflects on the Learning Process
  - Data rich, information poor
  - The transfer of data to information is a unique individual experience
- What is e-Learning?
  - Why e-Learning is important
  - The e-Learning environment
  - The many elements of e-Learning
  - A Distance Learning Example
  - Tools for e-Learning
  - Model e-Learning projects
  - Design Considerations for Effective e-Learning
- Information Literacy and Internet Concerns
  - Searching the Internet
  - Behaving (Netiquette) on the Internet
  - Filtering and other issues: Can we control the content of the Internet without censorship?
  - PICS: The Platform for Internet Content Selection
  - Plagiarism and Copyright Violation
  - Other problems with Internet use

REFLECTIONS ON THE LEARNING PROCESS

Education is all about helping learners learn and this process involves a lot more than a casual acquaintance with data such as happens when surfing the web. Too often students and teachers equate the collection and organization of Internet data with learning. We would not, in a science lesson, equate creating a chart of data about distances traveled by test egg mobiles with an understanding of the first law of motion. The same distinction applies to all Internet activities. It is essential to make the distinction in the learning process, at all levels of education, between

\(^2\) A paradigm shift is a radical change in the way an essential component of one's world (eg. education) is viewed by a culture or community.
collected and organized "data," "information" that leads to "knowledge," and the "wisdom" that comes with "understanding" knowledge. As we will see, technology can play a larger role in this process than simply facilitating the collection and organization of data.

**Data Rich, Knowledge Poor**

Teachers more than most other professionals should understand and appreciate the difference between *data* and *information*. Data are the raw material of information. Data are organized symbols (numbers, letters, pictures) that are representative of events. Data have no *meaning* per se—in and of themselves. Meaning implies understanding, which implies cognitive activity of some kind. Data are like the bricks and mortar and other materials that make up a building. It's only when the builder puts everything together and people move into it that the house becomes a home. Likewise, it's only when the brain makes sense of the data—once the mindacknowledges and assimilates the data—that they become information.

Shannon and Weaver (1949) define information as data which "reduce uncertainty"—data which bring greater understanding, lead the mind to new awareness of the world, are accompanied, perhaps, by an element of surprise (the "aha" response).

So we are not informed when we are told something we already know. If we open a book and read that "2+2=4" nothing much happens in our mind, except perhaps the question: "Why on earth am I reading this book?" No, we are informed when the data we come across (read about, experience, are told) extends and enriches our mind in the short or long term. When we are informed our minds, and thus our lives, in some very real sense are changed.

Debons et al. (1988) are careful as Information Scientists to delineate a continuum they call the Knowledge Spectrum (Fig. 8.1 on next page). The continuum starts with an occurrence called an *Event* which constitutes "some condition or change in the state of the world." The Event is captured in our minds using *Symbols*—essentially meaningless representations requiring *Rules and Formulations* to give them significance. Once the symbolic representation of the event has been organized using the rules and formulations, *Data* are produced. Strictly speaking, the mind has not yet been engaged. We are in the *Data Driven Segment* of the continuum.

Once data is acknowledged by the senses, the mind (cognition) becomes involved. If the data "reduce uncertainty" *information* results from the experience. The mind is literally changed physically—new connections are made in the brain—by the growth in knowledge that information in this Debonian sense brings. As Oliver Wendell Holmes observed: "The mind, stretched by a new idea, never goes back to its original dimension." We are now in the *Cognitive Driven Segment* of the Knowledge Spectrum.

The information is added to the mind's store of *knowledge* when the intellect brings understanding to bear on the information, enabling the mind to use the knowledge "to analyze situations and to put things into their proper perspective" (Debons, 1988).

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3 Data is the plural form of the word. Datum is the singular form. Strictly speaking, one should say "a datum is..." and "data are..." However, in everyday usage Data is used as a singular or plural noun. Thus it is correct to say either "Data is..." or "Data are...". (you will find both in this text). According to Webster's Random House Dictionary (1991 edition), the word "datum" is rarely used.
Problem-solving does not happen in a vacuum; it arises from a knowledge base sustained by an informed mind. The final stage in the Knowledge Spectrum is *wisdom*, which brings a set of values to bear on judgments that call on the store of knowledge accumulated through experience.

If it is true that knowledge is power and that those with access to knowledge can compete most effectively for a fair share of the available "wealth" generated in a society; if it is also true that education is the primary formative experience that puts the keys of knowledge acquisition into a child's hands, then it follows that education is in every sense the key to survival in today's information society.

Every teacher is an educator with a mandate to educate—the word comes from the Latin *educere*, which means to lead out, to lead from, to challenge, to cause to advance. A prerequisite for the formation of an educated individual is the establishment of an environment in which that mind will be encouraged and stimulated to experience a multi-faceted world at a level that is consonant with each individual's stage of cognitive development.

**The Transfer of Data to Information is a Unique Individual Experience**

Debons (1988) describes the process whereby data are *acquired, transmitted, processed* and *utilized* on the way to becoming of value in decision-making. This Debonian model of an information system includes another key component—*transfer*—which is the end product of an
information system. This is when the data, because they are new⁴, impact the human mind, reducing uncertainty and forever changing the individual's knowledge base.

For the teacher this has many powerful implications, not least of which are the following:

A student is not informed by the mere attempt to convey data.

Remind yourself of how many times you have sat through a class, or read page after page of a book, and neither averted to, nor understood, a single thing!

A student is not informed when the data are already known.

Remind yourself of how many times you have sat through a class, or read page after page of a book, and learned nothing you didn't know before! Indeed a common criticism of poorly designed computer-based learning is that it expects students to mindlessly review material that is already thoroughly learned. On the other hand, well-designed computer-based learning will recognize and remember individual student characteristics and capabilities, and will challenge the user to move to higher levels of learning by addressing that individual's unique learning needs.

One student will not experience the Event the same way as another student.

Howard Gardner (1993, 1999) has theorized that we all differ from one another in the balance of "intelligences" that make up our minds. We don't all learn the same way and we each have optimal learning strengths among the eight or nine types of intelligence that we bring to the classroom. Additionally, students bring to the classroom differing Learning Styles⁵; each will follow the Knowledge Spectrum path differently, responding to different Events at different times delivered differently.

Moreover, cognitive development is not a linear, but a cyclical process. As described by Fischer and Rose (1998), the student learner will repeat the move from Event to Wisdom at different speeds, from different cognitive base levels, and with differing levels of accomplishment throughout the school years.

The transformation (transfer) of data to information is thus a unique, individual experience even when shared with others. Unfortunately this individualization of learning is difficult to achieve when most teachers are expected to work with many students at once. The typical teacher-pupil ratio, while much better than a hundred years ago, is still unsatisfactorily disproportionate in most of the classrooms in our schools. While the national average in U.S. public schools is about 17 students per teacher, this average belies the fact that most teachers have closer to 25 students in their classes. 10-15 students per class should be the norm. 1-1 would be an ideal.

Tailoring course content to individual needs is thus a major challenge for even the best teachers when they have to plan lessons for so many students. Teaching teams is one solution for the classroom; another is the "pull-out" program for both enrichment and remediation. As you might expect, technology also comes to the rescue. In Chapters 5 and 6 we took a look at some

⁴ Data can be "new" even when it is old. I can know what a particular piece of music sounds like, but at some later time I may relive the newness at a deeper level of familiar experience.

⁵ Although there are many descriptions and classifications of Learning Styles, the agreed upon core is VAK (Visual, Auditory, and Kinesthetic).
Chapter 8: E-Learning and Information Literacy

of the commercially available software and web-based packages for "integrated learning." These combine varied, multimedia instruction and drill with individualized assessment. The best of them also generate a "formative assessment," providing not only the means but also the materials for improving learning in problem areas. Because such a solution is delivered over a network, it falls under the umbrella of "e-Learning." Although we will not expand upon "integrated learning" systems in the chapter, we ask you to keep them in mind as you learn about other models and modes. Other e-Learning solutions, such as WebQuests and Hunts, will be discussed in Chapter 9, when we look at the Internet as a source of learning activities as well as data.

WHAT IS E-LEARNING?
e-Learning means different things to different people. In the context of this book, we can define e-Learning as learning that takes places over a network. This mode of learning existed before computers. Women in various societies have used the postal network to gain educations otherwise denied to them. Since the early 1900s, radio was used to bring education to students in remote locations of the Australian outback. Closed-circuit TV also has been used for this purpose. The introduction of the networked computer into the mix has brought e-Learning to center stage because, with the Internet, the learning community is global. The learning may involve a teacher at one end of the line and students, singly or in groups, at the other. Alternatively, students from different schools (local, national, or international) may be networked together for purposes of interaction, discussion, joint project work, and so on.

Why e-Learning is important
Up to this point, this text has been devoted to convincing you, the future teacher, that technology can enrich the classroom learning experience and facilitate the many "outside the classroom" tasks and responsibilities you will face. You have been introduced to an exciting new, digital world, in which boundaries are stretched to global, and extra-global, proportions and tools are portable, multi-faceted and always "on." It is time now to show you how this vision can in fact become a learning environment for your students. This is e-Learning.

We will see that e-Learning promotes not only technology fluency, but also the 21Century skills of problem-solving, communication and collaboration. It has another important value: it promotes diversity values.

The United States, along with societies the world over, is becoming increasingly diverse in terms of its population. The melting pot is still a long, long way from evolving into a culturally homogeneous mass. Multiculturalism is a key focus in education because children need to learn about, and live with, diversity more than ever before. Just as knowledge is power, so awareness and understanding of difference will promote acceptance of difference and lead to a more equitable society where the rights of all, regardless of race or gender, are given an equally sympathetic ear.

e-Learning serves the goals of multiculturalism by enabling students in rural communities to reach out to those in urban areas; it is enabling students in wealthy districts to interact with those less well-endowed; it is enabling students of one racial background to collaborate on
multicultural projects with those from another. In pockets of progress, some of which have been profiled above, distance education is making a difference.

As networking technology takes increasing hold in schools, these cross-cultural, cross-race, cross-economic interactions will become the rule, rather than the exception. While this interaction will not remove differences of culture, race, and economic status, it will open children's eyes to the realities of those differences and help them to become more tolerant toward each other. It is the duty of every teacher to work with the families and the communities to promote multiculturalism with a view to breaking down prejudice, replacing it with a celebration of diversity. Appendix D further explores this topic.

The e-Learning environment

Keep the conventional classroom in mind as you read this list of the traits shared by most e-Learning experiences:

- **Learning can take place anywhere.** Because the "learning content" is accessed over a network, it is available anywhere the network can be accessed. As you now know, this can be at the beach, in bed, in an airplane, in the space shuttle, at the bottom of the sea. The physical boundary of the classroom is not required for e-Learning.

- **Learning can take place at any time.** Similarly, the time-frame for learning is determined not by a schedule of bells, but by the preferences of the student(s). The exceptions to the anytime rule are teleconferencing, videoconferencing, and chat, which are synchronous events.

- **Learning content is available in multiple media.** The e-Learning experience is accessible in a multitude of ways. Typical experiences include text, audio and visual content, in both synchronous and asynchronous modes.

- **Learning is not a one-shot experience.** Essential to e-Learning is the ability of the student to revisit "data" and "information." This is possible because learning "assets" are digital and a student's contact with data becomes part of the digital archive. Chats, e-mail, online conferences, activities, drills, assignments and assessments are part of an individual's learning experience archive.

- **Learning does not require the physical presence of a teacher.** What?? Well, you know about videoconferencing, streaming video, chat, bulletin boards, blogs, podcasts, and web pages. Imagine teaching students using only these tools. A paradigm shift, to be sure, for, as we have discussed often in this text, 1-1 or face-to-face is often the most effective communication mode of all. However, imagine how useful it would be for the visual learner to have a lesson digitally "replayed" over the Internet; or for the tactile,

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6 An example of this is taking place in rural New Zealand and Australia, where remote schools are sharing network connections and classroom experiences.

7 Seymour Papert and others would add "cross-generational" to this list.

8 You will remember from Chapter 5 that any individual snip of learning content can be digitally archived for retrieval and reuse—this creates an "asset."
concrete learner to be able to read and reread a lecture while listening to a voice recording or digital speech.

- **Learning does not require the physical presence of other students.** This makes more sense, probably. As we discussed in Chapter 7, networks and the Internet create a potential global community. Which brings us to one of the most powerful aspects of e-Learning:

- **Learning requires Communication:**

  - **The learning process supports, encourages and often requires Cooperation.** Cooperation can be defined as two or more individuals contributing to a set of Information or to a learning outcome or project. Contributions can be images, URL's, data, journals, e-mail messages, or IM's. Cooperation is not, of course, a new teaching method. "Two minds are better than one, four hands are better than two" is a very old adage and the best e-Learning events take advantage of it.

  - **The learning process supports, encourages and often requires Collaboration.** Collaboration can be simply defined as two or more individuals sharing Understanding and providing mutual feedback. The best teachers recognize that their role is often to collaborate with the student, and this is even truer with e-Learning events. The network, however, allows for an unlimited number of collaborators, many of whom the e-Learning student will never meet face-to-face.

  - **The learning process requires Problem-Solving.** Drill and practice within a "known" data set is not e-Learning (although there is too much educational software that pretends that this is true). Problem-solving activities are an essential component of the challenges that require cooperation and collaboration.

It is through cooperation and collaboration that the individual's learning experience is most enriched. Further, problem-solving challenges not only stretch students to achieve Knowledge at a higher cognitive level (Fischer, 1998), they serve to motivate students. Roschelle and others, in their review of the effects of new technologies on learning, note that "performing a task with others provides an opportunity not only to imitate what others are doing, but also to discuss the task and make thinking visible...Reports from researchers and teachers suggest that students who participate in computer-connected learning networks show increased motivation, a deeper understanding of concepts, and an increased willingness to tackle difficult questions." (2000).

That said, e-Learning takes a multitude of forms, ranging from a single student researching "whales" on the Internet and reporting back to a teacher, to global collaborative research projects in which students at multiple sites and levels collect, share and analyze data and then share their new Understanding with teachers and scientists.

Fig. 8.2 demonstrates the possibilities for e-Learning activity structures. The "star" at the center of the diagram is the "core" of e-Learning that we will explore later in this chapter.
For now, let us follow an example of an e-Learning activity that falls under the umbrella of what is often called "Distance Learning." In this model, a teacher uses the Internet (or LAN) to instruct students in a remote location. It is characteristic of Distance Learning for multiple means of communication, cooperation and collaboration be available to students. We will be looking at videoconferencing and Internet collaborations as well.

A Distance Learning Example

A striking example of the effectiveness of Distance Learning is provided by Richard Wallace, who teaches at Ballyclare High School in Northern Ireland. Here is his account of the year he used Distance Learning to prepare his students for the national United Kingdom General Certificate of Secondary Education (GCSE) exam in Information & Communications
Technology (ICT). The Blackboard Course Management System (CMS) was used to manage online discussions and the exchange of learning materials and assignments.

As a result of my International Masters last year I decided to radically alter my teaching methodology with one particular class. They were very bright, highly motivated pupils and would have had little or no trouble passing their ICT GCSE whether or not I had changed the way I taught. I had been challenged by the work we did on the Masters to re-examine the effectiveness of my teaching and to investigate the use of online or elearning in a school situation. After 30 years in the same school teaching the same subject I suppose I just believed that ‘I taught and they learned’ and that was the end of the story. That was a mistake on my part.

We began the year together by having a chat and follow up discussion on what type of teacher they would like me to be. From that process I discovered that they wanted a teacher who knew what he/she was talking about; a teacher who trusted and respected them; one who provided notes that were sufficiently detailed but not excessive; one who highlighted the key points; one who was aware that they learned in different ways and who made an effort to accommodate this; one who prepared them for the actual exam that they had entered and not just taught them irrelevant facts that he/she happened to know; one who showed how the whole subject fitted together so that they knew what, when, where and how to do things during the year that lay ahead of them. This type of information could easily have been discovered in a face-to-face class discussion but the major benefit of using Blackboard was that everyone in the class contributed (ie I was not only getting the opinions of those I chose or the most vocal) and the transcript of the chat enabled us to have a further discussion to clarify some of the issues.

I wear many different ‘hats’ in the Northern Ireland education system so, as well as being a teacher and one of the deputy Headmasters in the school, I attend various meetings, seminars and conferences. It was normal for me to be in the classroom some of the time and was elsewhere for most of it. Sometimes I was in school and my Systems Manager (who is a qualified teacher with a teaching load of 10% approximately) was with my class. At other times I could have been anywhere in the world. My students and I chatted synchronously and discussed many elements of the syllabus asynchronously either on Blackboard or by email. Some of my Masters colleagues, including John Anderson and Mary Mallon (whose Case Study is at the end of this chapter), joined me in the Virtual classroom from the comfort of their homes. We became a group of learners who used the Blackboard CMS as the main teaching resource. I provided them with hyperlinked notes, PowerPoint presentations, a web based Case Study for one of their assignments, a huge glossary of terms, exemplar materials, helpful and relevant external websites, key points and typical examination questions. I used a combination of the assessment tools in the BB Virtual Learning Environment (VLE) and the ‘digital dropbox’ for questions which required extended answers.

It really took a great deal of effort to set it all up and then there was the time factor for the pupils to take it all on board. I had realised the huge amount of time investment on my part but hadn't really appreciated how much longer it took to deal with each of the topics on the syllabus than would have been the case in ‘chalk and talk’ teaching. I soon
realised that using technology in this way is more than just the provision of online materials. It is the level of interaction that really makes the difference. As someone said ‘you can take a child to a computer but you can’t make him/her learn’.

I capitalised on the novelty factor which the pupils were experiencing. In no other class had anyone ever bothered to take account of their individual learning styles nor had they planned out, and made available, the whole course on a week by week basis. We communicated a lot on Blackboard and by private email and saw each other occasionally face to face. All of the materials were online 24/7 but, while I made myself available for reasonable amounts of time, I had to draw the line on occasions. The pupils did spend much more time on topics than they normally would have done. At least I was now sure that more of them knew what I was talking about because of the amount of feedback I was receiving. I suppose that 'normal' lessons do have a certain amount of feedback but it tends to end and die at the end of the lesson. With online learning it continues well after the bell has rung.

My "unresearched and unvalidated" conclusions were that the workload for the teacher took two or three times as long. But, in the end, the learning was "better" and has more chance of becoming the foundation for lifelong learning. When I meet the pupils they still talk to me with affection about their unique experience. What they liked most was the "big picture" approach. They knew where everything was on the site and so it was easier for them to locate the materials even if they were off school or working from home in the evenings. They didn't mind investing their time in the extra communication with me. In fact, in some cases, many pupils have remarked to me how much they appreciated this almost individualised approach that they were receiving from me.

There were 22 pupils in the class. Fourteen of them got an A* grade, seven got an A grade, and one, who had a serious medical problem in his home, got a grade D--just to keep me humble! Normally less than 10% of the exam population in the British Isles would get a grade of A*.

I have secured a secondment from the classroom for a year with part of my brief being to finish the materials. I am now working with the local Examinations Board on an official research pilot to provide this course for all schools in Northern Ireland. Progress is slow because so many other equally valuable and worthwhile things about e-learning get in the way, but I will get there in the end and Northern Ireland will have its first online high currency course in time for the completion of the province-wide computer provision. I hope to begin research trials with over 100 pupils from 5 different schools and, from this, John and I will develop a methodology for teaching sixteen year old pupils in this way in our schools. We have realised that the use of a VLE in the classroom is different from that experienced by both students and tutors in Further or Higher education and have set about investigating these differences for both teachers and pupils. The findings and evaluations will be published later on our website at http://www.elearningfuutures.com.
Tools for e-Learning

The above e-Learning experience makes use of VLE, or Virtual Learning Environments, an umbrella term used in the United Kingdom for systems that support and deliver e-Learning. The specific tool, BlackBoard, is what provides the "core" for the learning exchange of data, understanding, and eventually knowledge.

As you might expect, new e-Learning tools are becoming available daily. These tools fall into five categories: computer applications, web-based integrated learning systems, web-based classroom applications, web-based school-wide CMS, and videoconferencing applications. We will highlight just a few tools in each category. A 6th category, the online "social network," is enormously popular with today's students and adults. Because of the dangers of an "unmanaged" and anonymous community, however, these services are not currently recommended for education (unless they are embedded in an educationally safe and secure service).

Computer applications Software installed on a laptop, desktop or handheld computing device can be used for e-Learning when it provides for communication, cooperation and/or collaboration over a network. Many of the productivity applications introduced in Chapters 5 and 6 can support e-Learning

- **Artemis**—This tool, for handhelds and desktops, provides tools for data analysis and collaboration. It begins with Driving Questions and insists upon accurate record-keeping. Users are able to connect to a set of web-based tools and information sources. A simpler tool is called Model-It. Pico-Map is a free tool for handhelds that creates interactive concept maps.

- **FirstClass**—Although this application is primarily an e-mail service, its ability to provide conference rooms and group calendars, serve web pages, record and transmit sound files, and chat make it a powerful tool for e-Learning. Users must have the "client" on their computers and have access to a central First Class server.

- **iChat, iChalk**—In the Apple environment, these tools provide powerful tools for communication and collaboration across a LAN or WAN.

- **MicroWorlds**—In its newest configuration, this Logo based tool enables students to create and manipulate simulated multimedia environments with the addition of global, interactive collaboration.

- **Squeak**—A tool developed for e-Learning in the k-12 environment. Squeak supports media elements, requires problem-solving, and can be used for P2P real-time collaboration via voice communication, chat, or file sharing.

- **Microsoft Exchange**—Once NetMeeting, Exchange provides web conferencing, video conferencing and IM capabilities to group. Additionally, the real-time sharing of some documents is supported.

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9 the user's desktop, laptop or mobile device
Chapter 8: E-Learning and Information Literacy

- Skype – a free application that enables users to make peer-to-peer voice over IP (VoIP) low cost phone calls to a cellular or landline phone used by another Skype user.

- iVisit supports text and videoconferencing across platforms and does not require that data be relayed through a server, making it useful in a non-networked classroom.

Web-based Integrated Learning Systems (content providers) — The best of these provide tools for communication, cooperation, collaboration and publication in addition to content delivery and assessment tools.

- QuickMind is a commercial e-classroom from Sunburst Learning Solutions, which also creates educational software.

- Kidz Online — This environment for e-Learning is dedicated to the development of 21st Century technology skills, including networking. It includes web site hosting, instruction through streaming video, and much more.

Web-based classroom applications — These can be used by a single teacher to create an e-Learning activity or an e-Classroom. Chapter 9 expands upon this list and discusses the WebQuest in some detail. Bernie Poole has developed a WebQuest which is designed to help teachers learn about “Weaving the Web into the K-12 Curriculum.” This resource may be accessed at http://www.pitt.edu/~edindex/WebQuests.

- NiceNet — The Internet Classroom Assistant allows registered teachers to create a free online classroom — ad free! This is perhaps the most powerful tool available to the teacher, for it allows for the creation of multiple and global "classrooms."

- MemberClicks — This web-based company creates and hosts interactive databases, data display and collection solutions. It is not inexpensive, however.

- TrackStar — Organize web links into lessons with this free tool. You can also search the large archive of completed lessons.

- Yahoo Groups and Google Groups — Teachers can easily create a short-term or year-long e-Learning group, complete with (limited) document sharing, chat, calendaring, and free e-mail.

- BlogDrive.com — This site provides free hosting for blogs, or web logs, which can become collaborative environments.

- Wikispaces — teachers can create a free and extensive classroom WIKI with an account at this service provider.

Web-based School-wide CMS These generally require a significant subscription expense. Some require in-house support as well. They do not supply content; they supply communication tools.

- Think.com was developed by the Oracle telecommunications program to support free e-Learning in the k-12 environment. Originally developed to provide free e-mail accounts to UK students, it grew into a full, web-based environment capable of delivering all of the components we have identified for e-Learning; it is being used throughout the UK.
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- **eClassroom**—A "turnkey\(^{10}\)" solution for schools wishing to develop virtual classrooms (Distance Education) quickly.

- **Elluminate**—This new solution provides a "webcast" environment, including chat, virtual whiteboards, voice and webcam\(^{11}\) support, file display. It is widely used in the global ICT community.

- **Adobe MacroMedia Breeze**—An e-Learning environment developed for business but very useful for education. It includes web conferencing.

- **Moodle**—A cross platform "open source\(^{12}\)" application for producing internet-based course content similar to that created by BlackBoard. This is superb, but it requires significant support from in-house IT personnel.

- **WebCT**—This is perhaps the most used environment for universities, large schools and school districts. It has recently merged with *BlackBoard*.

**Videoconferencing** is a special type of e-Learning. It is integrated into several of the tools above. We are presenting it separately because it requires special hardware, a digital video camera and microphone. Video conferencing can be 1-way or 2-way.

A one-way conference is often used for Distance Learning: the camera records the teacher or presenter on one end. The students view the live video or archived video on a computer (or projected onto a screen) at the other end, and respond either via a realtime chat tool or an asynchronous tool (bulletin board, blog, etc.). Tutorial e-Learning uses the video format but does not require that students respond.

2-way videoconferencing requires that synchronized cameras and microphones be available at both ends (some conferences include multiple "nodes"). This is perhaps the most exciting of all e-Learning for the student. The setup can be as simple as inexpensive digital video cameras and microphones or as complex as studio conferencing with high-end equipment to support panning, delayed action and title effects. It is most effective if the connection speed is the same at both ends and the cameras have similar resolutions. A dial-up connection can not generally support effective conferencing—cable modem or DSL are minimally required. Studio conferencing requires at least a high-speed ISDN connection.

Most conferences are arranged by teacher-to-teacher or teacher-to-organization contact. This direct connection is recommended, for planning issues are numerous. Content, of course, is key—students generally do better in a videoconference if they have a knowledge base and a set of rehearsed questions. Time is an issue as well—consider both the length of the conference and the synchronization of clocks! It goes without saying that the teacher needs to do a "dry run," if possible, the same way she would visit a local museum before bringing her class there.

\(^{10}\) As its name suggests, a turnkey solution is "all in one, out of the box"—including software, a server (or remote installation on a school server), all files and modules

\(^{11}\) Remember that a webcam is a portable digital video camera

\(^{12}\) You may remember that "open source" software is developed by programmers and made available, generally over the Internet, for free
Locating a video conferencing partner is not difficult. AT&T maintains a current directory of museums, schools, and other organizations that have video conferencing studios (http://www.kn.pacbell.com/wired/vidconf/directory.cfm) as well as links to other directories. Teachers that have access to similar studios can schedule programs the same way they would schedule field trips. In fact, these events are often referred to as Virtual Trips.

Classroom-to-classroom video conferencing, over the available Internet connection, requires only that a teacher make a connection to another teacher. Using a tool such as iChat AV or Microsoft's integrated conferencing, students can easily "talk to" students, authors, or experts on the other side of the state, country or globe. e-Learning project registries such as that maintained by Global SchoolNet (http://www.globalschoolnet.org/index.html) will help a teacher locate other schools that have videoconferencing capabilities. There are numerous "video chat rooms" online, many of which provide free space and free software for users. Teachers must use these with caution, however, for the most prevalent users are NOT school classrooms.

At this point you may be feeling overwhelmed or frustrated by a lack of experience or access to tools. You may be thinking—e-Learning sounds great, but what do I use it FOR? It is appropriate at this time to take a breath and remember that the Internet is a huge resource. As e-Learning buzzes through the k-12 school community, it generates a plethora of excellent online projects, ready made and supported by an experienced teacher community. In the next section will we highlight a few of these, indicating the e-Learning modes that they demonstrate.

**Model e-Learning Projects**

- **Local, asynchronous, text mode, web-resource based**—These are organizational and teacher websites and teacher-created activities. Many contain media elements, but most are text-based. Publicly posted, they are available to classrooms and teachers in a global community, although such access is generally "invisible" to the creator. Many contain a significant number of activities for students, which may include a WebQuest activity. These work well as collaborative or individualized e-Learning within the classroom.

  - Colonial Quilts (a Ribit inquiry)—short-term http://ribit.tielab.org/ribit_show.php?firstview=true&sign=&viewnumber=&resultsperpage=10&id=54
  - Powerful Words – a webquest about the Wabanakis of Maine—http://www.leasttern.com/Wabanaki/PowerfulWords/
  - X-BLOCK provides training in online safety at many levels—http://xblock.isafe.org/

- **Global, asynchronous, data collection, web-based**—Activities such as this invite global participation. It is up the to "in-house" classroom teacher to guide the learning experience.

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13 Many universities, technical schools and district training centers have videoconferencing facilities.

14 You will learn in the next chapter that Virtual Trips can also be entirely Internet based.
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- Technospud Projects—organized by Jennifer Wagner—different projects across the school year, ranging from Oreo eating to FrootLoops math—short-term—

- Journey North—one of the longest standing projects, students follow the migration of the Monarch butterfly, sharing data from member schools—[http://www.learner.org/jnorth/](http://www.learner.org/jnorth/)

- Human Rights 101 – portal to collaboration projects for high school students – civil rights themes—[http://www.thirteen.org/edonline/hr101/](http://www.thirteen.org/edonline/hr101/)

*Global students, synchronous and asynchronous, data collection, web-based with hands-on or in-house elements* Such e-Learning activities often require some teacher training or a small fee. They tend to be long term projects and often include multi-media elements.

- CIESE Online Classroom Projects—These cover many types of activity, from primary document exploration to data collection to collaboration—science topics - [http://k12science.org/currichome.html](http://k12science.org/currichome.html)

- The Jason Project—multiple projects with an environmental focus—students engage in virtual science and collaborate with field scientists in remote locations—there is an option to bring a student group to the study site—[http://www.jasonproject.org/](http://www.jasonproject.org/)


- Center for History and New Media – online tools free to educators, in addition to a vast resource bank—[http://chnm.gmu.edu/index.php](http://chnm.gmu.edu/index.php)

*Design Considerations for Effective e-Learning*

E-Learning can be hard work, both for the student and the teacher, with Distance Learning being the hardest of all. Drop out rates in Distance Learning courses (as opposed to shorter term learning activities that use a Distance Learning model) are typically higher than for face-to-face courses. It takes a significant amount of time to create an effective web-based learning project, much less a WebQuest or Distance Learning course. Even the teacher who embraces one of the ready-made projects, such as those listed above, will find that the first implementation is time-consuming; few projects will dovetail neatly into a teacher's curriculum, methods and class profile.

The following are some of the considerations that the teacher should keep in mind when implementing or designing an e-Learning experience, event or course.

- Students need to be able to easily find all the information they need.

- Information at the site should be accessible to the student audience, appropriate in content and reading level, and meeting assistive requirements (if any). Where files or documents are uploaded or provided, they must be in a format that any user can read.

- Students need to find the online presentation of information attractive and accessible. It would be a waste of time to prepare an e-Learning project for a class of students who had no access to the Internet outside of the classroom or who lacked the funds to purchase software for home computers.
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- Students need to feel like they belong to a community. Belonging requires recognition (That's your work!), positive and supportive feedback (rules for contribution need to be established for younger students), and opportunities for casual communication or sharing.

- Students need to feel like they are connected to their instructor. Again, communication and feedback are essential!

- Assessment should be formal and at least equal in rigor to that expected in the face-to-face classroom. Many e-Learning projects lend themselves to authentic assessment as well as standard methods, but assessment tools (rubrics, checklists, corrected essays) need to be part of the design of the program, even if they only exist in-house and in-print. Furthermore, in the k-12 environment assessment should include "how the student managed" as well as how the student learned: collaboration and cooperation should be assessed.

- Students need to be directed to keep up with the course or to keep pace with the assignment, especially if collaboration and cooperation are keys to eventual completion.

- The Web is an invaluable tool and information resource and should be used whenever applicable as an extension to the content for the course. The Librarian should also be seen as an invaluable resource. He or she can provide not only resources, but Information Literacy lessons and support (this is the topic of the next section).

- Constructivist methods go hand-in-hand with technology and should be planned for in the design of the course. It is beyond the scope of this text to undertake a description of Constructivism in the classroom, so we will limit ourselves to what is becoming a cliché: The teacher must be a Guide on the Side, not a Sage on the Stage.

e-Learning is not a 21st Century miracle drug for education, nor is it a placebo. Potentially, it is both. For the time being, it is the teacher who will determine its value in the classroom. We end this section with a reiteration of David Thornburg's vision for the 21st Century that opened chapter 7: "Modern technologies are space collapsers, time shifters, and creative tools that extend our reach."

INFORMATION LITERACY AND INTERNET CONCERNS

Information Literacy, from the point of view of the educator, is the ability to recognize when information (our "data") is needed and then to have the ability to locate, evaluate, and effectively use this information in the learning process. For most of the history of education to date, this has meant being able to read, listen, write and speak effectively. With the advent of the Internet (and now Internet 2), a new e-Learning definition has come to the fore, a cause championed, and rightly so, by librarians. Information literacy, in the e-Learning environment, breaks down to three skills: searching the Internet, organizing and sharing data, and constructing learning based upon acquired information15. We will deal here only with the first of these skills. Applications and digital tools for organizing and sharing data have been discussed in previous chapters. It is beyond the scope of this text to dwell on the last skill, critical though it

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15 You are reminded that these are by no means the only skills necessary for the effective use of technology in the classroom! But they are a good start.
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is. The American Library Association's Information Literacy resources provide further information at the following URL, which can be slow to download: http://www.ala.org/aaslTemplate.cfm?Section=Information_Power&Template=/ContentManagement/ContentDisplay.cfm&ContentID=19937.

Searching the Internet: Search engines

Internet 16 "search engines" fall into three categories: spiders, directories, and database searches.

- **Spiders**, or crawlers, are robot programs that taste all accessible web sites and try to match your "keyword string" to their criteria. Google, AskJeeves, Hotbot, and Alltheweb are just a few of the spiders currently available. Each engine employs search strategies of its own. Some use a **breadth-first** approach, scanning across the higher-level web pages in a site first on the assumption that the most used sites are those most likely to yield the required information. Other engines use a **depth-first** search, drilling down the hierarchy of web pages in a site on the assumption that a website that yields interest from a dedicated base of users (a niche of users, if you like) will return a higher degree of **quality** information. Other engines will count as a **hit**17 any site where at least one of the search keys you listed is found and search for a hit count. An engine using this strategy will find more hits, but the majority of the hits may not be very useful at all. Most spiders will search **META content**18, headings, titles and full text.

- **Directories** are created by real people, who classify each web site into a pre-existing category or topic. The search is more like a traditional library catalog search than a keyword search; the path followed by the search engine is displayed, as are links backward to a more general topic (these are called **bread crumbs**). Examples of directory engines are Yahoo, About.com and the AOL search engine.

- **Database searches** are the most lucrative, often, but also the most frustrating. The Internet contains many databases that are, by the nature of their hosting or creation, "invisible" to spiders and directories. Many of these, such as **ProQuest**, a database of full-text newspaper and journal articles, and **SIRS**, a database of full text articles on a wide variety of cultural, health and political issues, are invisible because accessing them requires a secure (and often fee-based) password. Others, such as **ArtCyclopedia**, are invisible because their hosting system or content is not accessible to spiders. Luckily, search engines exist for the accessible. Google Scholar (http://scholar.google.com/) and Infomine (http://infomine.ucr.edu/) are two of them. Many of the fee-based databases are also available through school and public libraries. In fact, a teacher who knows about the locally available library resources can greatly enrich her students' e-Learning experiences.

Search strategies

You should try more than one engine and more than one database when researching a topic, unless you are fortunate enough to find what you need first time. You should also try various

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16 As of this writing, it is unclear how effective any search engine is at searching the Internet.
17 A hit is a match—a search engine displays a list of sites, documents, images that match your search terms
18 META tags are "invisible content" added to the HTML of a web page by its author. These include keywords, authorship and a description.
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words or sets of words as the key for your search, especially if your early attempts bring up too many hits to be able to check them all out individually. This is where search strategies come in handy.

The more precise you can make your search, the fewer hits you will find—which is often just what you want. For example, if you use a search engine to find material on a subject such as "London," you will find thousands, if not hundreds of thousands, of hits. Lots of sites will have references to somewhere as well known as London. In fact, if all you want to do is find out data in general about London, you'll be better off looking it up in your online encyclopedia. But supposing what you want to find out is the Aldwych Theater schedule. A better search string (set of keywords) would be "London Theater Aldwych." This will turn up many hits, too, but at least most of them will take you directly to the information you are looking for. Try it!

A good rule of thumb in searching is to start with a more detailed search string (that is, one made up of a few—two or three—key words, rather than just one). Then reduce the complexity of your search key until you start to find what you are looking for. It is quite likely that your critical thinking skills will also become honed by frequent research over the 'Net. This is because there is so much information on every subject under the sun that you have to become discriminating and selective to avoid becoming overwhelmed by it all. A Web page devoted to strategies for searching the Web may be found at http://www.pitt.edu/~poole/strategies.html. A good tutorial for teachers and students in need of keyword selection skills can be found at the 21st Century Information Fluency Project (http://21cif.imsa.edu/tutorials/).

In the end, as we have said over and over again, knowledge is power. The more you know about a subject, the easier it will be to find what you are looking for, no matter how much data are out there, just as the better you know the highways and byways of a town, the quicker you will arrive at your destination, no matter what the state of the traffic on the roads.

**Behaving (Netiquette) on the Internet**

It is not enough just to search and find. In our age of e-mail, blogs, podcasts, phlogs (photo blogs), bulletin boards, listservs, chat and IM, conventional requirements as to social behavior are as important on the Internet as they are in everyday polite society. Such conventions are called etiquette; on the Internet, pardon the pun, they are called netiquette. When your netiquette is lacking, you run the risk of being flamed—i.e. told off in no uncertain manner!

Table 8.1 (next page) lists some of the Dos and Don'ts of netiquette recommended by Vincent Zema (1996). Teachers, parents, and students know that there are "dangers" involved in Internet use. We will discuss in the next section some hardware and software tools for promoting safe Internet use.
• **Don't** include the entire contents of a previous mailing in your reply.

  Do leave in just enough to indicate what you're responding to. Never include mail headers, except maybe the "From:" line.

• **Don't** reply to a point in a posting without quoting or paraphrasing what you are responding to, along with who said it. Otherwise other users may not know what you are talking about.

  Do quote briefly or paraphrase. If the original "Subject:" line was "Big dogs", make sure yours says "Re: Big dogs". Some REPLY functions do this automatically.

• **Don't** send lines longer than 70 characters. This is a kindness to folks with terminal-based mail editors or newsreaders. Some mail gateways truncate extra characters, turning your deathless prose into gibberish.

  Do learn what your mail editor does with your text.

• **Don't** SEND A MESSAGE IN ALL CAPS. CAPITALIZED MESSAGES ARE HARDER TO READ THAN LOWER CASE OR MIXED CASE.

  Do use normal capitalization. Separate your paragraphs with blank lines. Make your message inviting to your potential readers.

• **Don't** betray confidences. It is all too easy to quote a personal letter in a posting to the entire group.

  Do read the "To:" and "Cc:" lines in your message before you send it. Are you SURE you want the mail to go there?

• **Don't** make statements which can be interpreted as official positions of your organization or offers to do business. Saying: "Boy, I'd sure like to have one of them Cray supercomputers" could result in a truck at your loading dock and a bill in the mail even larger than your student loan.

  Do treat every post as though you were sending a copy to your boss, your minister, and your worst enemy.

• **Don't** rely on the ability of your readers to tell the difference between serious statements and satire or sarcasm. It's hard to write funny. It's even harder to write satire.

  Do remember that no one can hear your tone of voice. Use emotions (or smilies) like :) or :^) turn your head counterclockwise to see the smile. You can also use caps for emphasis or use 'Net conventions for italics and underlines, as in: You said the guitar solo on "Comfortably Numb" from Pink Floyd's _The Wall_ was "lame"? Are you OUT OF YOUR MIND????!!

• **Don't** make a posting that says nothing but "Me, too." This is most annoying when combined with the first or second of the Dos and Don'ts above.

  Do remember the immortal words of Martin Farquhar Tupper (1810-1889): "Well-timed silence hath more eloquence than speech."

Table 8.1 Dos and Don'ts of Netiquette (Courtesy Vincent Zema)

**Avatars** Increasingly, e-Learning and other interactive virtual communities make it possible for users to "show themselves" graphically, often as an animal or caricature. Needless to say,
avatar choice can result in some temptation to misbehave, especially when coupled with a suggestive "screen name." Remind yourself often than it is necessary for the teacher to administer the online world available to the students. This often means saying "No!"

The more you use the Internet, the more rules of the 'Net you will learn for yourself. A useful exercise, included in the Do Something About it section at the end of this chapter, might be to get together with some of your colleagues or classmates and brainstorm to come up with other Dos and Don'ts related to netiquette on the Internet. Be sure to include chat, bulletin boards, videoconferencing and IM's in your discussion.

Table 8.2 lists some "Tips for Going On-Line" from the Interactive Services Association of the National Consumers League (1996).

<table>
<thead>
<tr>
<th><strong>Tips for Going On-Line</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Be a little cautious.</strong> You're not going to know as much as you'd like about those you meet on-line. Some may pretend to be people they're not.</td>
</tr>
<tr>
<td><strong>Keep personal information private.</strong> Don't give your address and phone number to strangers. Children should ALWAYS have their parents' permission before communicating personal information. If they are under 13, parent permission is law in the US. In public areas, like bulletin boards and chat rooms, literally thousands of people may read messages.</td>
</tr>
<tr>
<td><strong>NEVER give out your password.</strong> Be skeptical of people online who ask for your password. No online service will ask its own members for passwords online. Refuse such requests. It's also a good idea to change your password frequently.</td>
</tr>
<tr>
<td><strong>Don't automatically believe everything you read.</strong> Most people you talk to online will be sincere and readily offer information and advice, but that doesn't make them experts. Don't substitute a personal opinion for professional advice or assume it represents an endorsement by the online service.</td>
</tr>
<tr>
<td><strong>Be courteous.</strong> Other online users can't hear your tone of voice or see your expression. They know only what you type. For example, typing all capital letters is considered shouting, while typing :-( (a sideways face) means &quot;I'm laughing.&quot; Other common abbreviations and &quot;emoticons&quot; are listed in Table 3.</td>
</tr>
</tbody>
</table>

Filtering and other issues: Can We Control the Content of the Internet without Censorship?

Objectionable or inappropriate material abounds on the Web. What we're talking about here are sites devoted to pornography (however that may be defined), hate groups, extreme violence and other inappropriate subject matter whose content may be considered unsuitable for children at various stages of maturity. The following "solutions" to this problem are not ranked in any particular order. Each is important.

**Solution #1: Acceptable Use Policies:** An AUP is a policy that covers the responsible use of, uses of, and consequences of the misuse of all network tools: networked computers and other devices, Internet access, LANs, e-mail, listservs (in-house), etc. Schools may have several policies—for students in different divisions and for faculty. In light of our discussion of the
importance of parent communication in Chapter 7, and for legal reasons, the AUP should be
signed by a parent or guardian and by the student. Check out the Web links that follow to see
some examples of both good and poor acceptable use policies. As Nancy Willard, Director of
the Center for Safe and Responsible Internet Use observed, "Be sure to include due process
information in your policy. This is something that is blatantly missing from most policies."

- At http://www.aupaction.com/aupsonweb.html you will find examples of AUP's from
  many school districts and schools.

- The NCES provides an overview of AUP use and content for schools

Solution #2: Discuss these issues with the kids: Nancy Willard is among the most
recognized spokespersons for responsible use of the Internet and has written a great deal on
the subject. Her website at http://responsiblenetizen.org is dedicated to promoting the safe
and responsible use of the Internet. Amongst her many recommendations is the importance
of education, of making children aware of "effective strategies for acquiring knowledge,
decision-making skills, motivation, and self-control to behave in a safe, responsible, and legal
manner when using the Internet and other information technologies." Early in the year,
teachers should talk with their students about the need for responsible use of the resources
available through the Web. A good idea, perhaps, would be to have the students visit the
Internet Do's and Don'ts website of the Computer Crime and Intellectual Property Section
(CCIPS) of the Criminal Division of the U.S. Department of Justice. Talk about the need for
responsible use of the resources available through the Web. Another good idea would be to
visit Dewey's web site from the FTC (http://www.ftc.gov/bcp/conline/edcams/infosecurity),
from which you can access a quiz for students called “Are You a Safe Cyber Surfer?”

Solution #3: Be proactive (i.e. vigilant) as a teacher: Teachers are charged with
maintaining a safe environment in their classrooms. Students (and their parents) expect the
teacher to provide protection from exposure to danger of any kind. While the students are
working online in a classroom/lab environment, the teacher should be alert and in a position
always to know what the kids are up to at their stations. Students won't try to get away with
things if they know they're likely to get caught! Vigilance can also involve occasional checks
of the browser "History."

Solution #4: Filtering software and hardware: According to E-Rate Central's Weekly News
for January 2001, "under a new federal law, included as part of a large spending package
passed by Congress and signed by President Clinton in the closing days of 2000, schools and
libraries will have to filter Internet access to be eligible for federal technology funding. "Any
school or library that receives discounted rates for Internet-related services under the E-Rate
program, or receives funding through LSTA or Title III, must adopt and implement an
"Internet Safety Policy" incorporating a 'technology protection measure' that 'blocks or filters
Internet access to visual depictions that are' obscene, child pornography, harmful to minors, or
any other locally determined material 'inappropriate for minors.' The Policy must also deal
with the safety and security of minors when using electronic mail, chat rooms, and other forms
of direct electronic communications (i.e. Instant Message services), with 'hacking,' and with
unauthorized disclosure, use, and dissemination of personal identification information
regarding minors. Details of these requirements, and a timeframe for their implementation, are
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still unclear (and may be subject to various legal challenges).” This act, called CIPA (Children's Internet Protection Act) has, in fact, been challenged by the American Library Association, but the Supreme Court upheld its filtering requirements.

Most public schools therefore have some type of Internet access filter or control. There are several types of filtering, which can be done by in-house software, web-based access control, in-house hardware, or a combination of all three. Filtering itself can be based upon an "allowed list" of acceptable sites, domains, and services, or a "blocked list" of unacceptable sites, domains, and services. Even the least diligent filter will block many educationally useful sites (such as breast cancer research), and allow many unacceptable sites.

Check out the following links to see some examples of filtering software as well as filtering Web search tools.

The following are Safe Surfing Web browsers or search engines for kids:

- Altavista (http://www.altavista.com) and Google (http://www.google.com) contain "safe surfing" settings which are optional and which apply only if this search engine is used from this computer.
- AskJeeves for Kids (http://www.ajkids.com) is AskJeeves' neat, and safe, search tool for kids.
- Awesome Library for Kids (http://www.awesomelibrary.org/student.html)—this is controlled search directory.
- Crayon Crawler (http://www.crayoncrawler.com)—download a Web browser and use its secure list for a monthly fee. Read a company profile and find technical support.
- CSI SafeSites (http://www.csisafesites.com/) is a filtered directory search engine.
- KidsClick (http://sunsite.berkeley.edu/KidsClick!/)—directory searching of sites collected by librarians.
- KIDWEB (http://www.email-connection.com/KWFINAL.html)—showcases this animated browser that sets up an exclusive Internet neighborhood of pre-approved sites and provides secure e-mail—software must be installed on the computer.
- OneKey (http://www.onekey.com/)—a search engine to which you can point your students—in partnership with Google, it provides safe searching and an opportunity for you to recommend sites to add or remove.
- Yahooligans (http://www.yahooligans.com) is Yahoo's Web search guide for kids.

The following are software filters or filtering systems:

- Bascom Global Chalkboard (http://www.bascom.com/) is an example of an externally controlled searching option for schools—users attempting to use a browser are directed to Bascom's search portal.
- Bess Internet Filtering (http://www.n2h2.com/products/bess_home.php) and Foolproof (http://www.riverdeep.net/products/foolproof/security.jhtml) will secure your network.
devices, and include firewalls—they contain hardware components, as does SonicWall (http://www.sonicwall.com/).

- Clean Surf (http://www.cleansurf.com)—family friendly Web filter. This installed software routes all Internet requests through a secure server that contains the database of blocked sites. It includes an e-mail filter.
- Net Nanny (http://www.netnanny.com) and Cyber Patrol (http://www.cyberpatrol.com) are workstation applications that work like Clean Surf—chat monitors can be purchased separately.
- WebWasher (http://www.webwasher.com/client/download/private_use/index.html) is a free application that needs to be installed on each computer or on the Internet server. It uses both negative lists and positive lists (that can be changed). It includes content filtering and privacy protection.

**PICS: The Platform for Internet Content Selection**

The fact is that the Internet in general, and the Web in particular, are more or less free of censorship. People can, within the confines of law¹⁹, distribute whatever they want in the way of text, still images, and video. The Internet is a global network. It spans national and international boundaries. Infringements of the laws of decency and proscribed speech in one part of the world may not be infringements in another. To put it bluntly, there is no way of controlling "unacceptable" material on the Internet without shutting down the Internet altogether (which some countries are attempting to do).

Developed under the umbrella of the W3C (World Wide Web Consortium), the Platform for Internet Content Selection (PICS) "is a cross-industry working group whose goal is to facilitate the development of technologies to give users of interactive media, such as the Internet, control over the kinds of material to which they and their children have access" (Miller, 1996). The ICRA (Internet Content Rating Association) is an international independent organization that facilitates the use of PICS standards, as well as ratings of other electronic media.

Control is very different from censorship. PICS is not a rating service, it is labeling protocol that allows rating services, such as the filtering products listed above and the ICRA, to share a common language for making rating judgments (most do not take advantage of this, employing human raters or robot scanners instead). The actual rating "label" is placed voluntarily in the code of website homepage by the content creator. Searches run through a PICS compliant filter, such as the AltaVista safe search and many web browser searches (with "safety" features turned on), access the URL, then check its ratings against their list. Some searches will therefore be slower.

Software systems such as CyberPatrol, or NetNanny do not use labeling systems that are common to the other systems, and they do not recognize labels used by those other systems. This means that they can each only monitor the content that has been labeled by their particular software. This is one reason for their failure to do a complete job.

¹⁹ Laws to protect children from pornography exist and are currently in a state of some flux.
Chapter 8: E-Learning and Information Literacy

PICS advocates a flexible blocking approach which separates the selection software such as NetNanny, et al., from the rating services. In this way, the filter software developers need only make their software PICS-compatible, which means that the software would be able to read labels from any source (because the labels themselves will be PICS-compliant). By using the software, the user—parent, manager, administrator—will be able to apply ratings based on their specific needs to control the Internet content to which specific users would have access. In other words, a filter set for "extreme violence" would filter the same sites, images, sounds, etc. in all filter media. Websites that do not contain ratings (a way to avoid filters) can be filtered out.

Control of content is not a trivial matter for teachers in schools where the Internet is made available to the students. Open, uncontrolled access would quickly lead to abuse. On the other hand, filtering systems often hamper teachers, and students, from finding the best and most relevant information.

In the end, as has been reiterated elsewhere in this book, the teacher should always come bundled with the hardware and software systems. When the teacher stays close to the children with a view to ensuring that they make optimal use of the learning environment, few problems can arise. But in a litigious society, situations could too easily arise where children are unwittingly given access in school to content that would deeply offend many parents, let alone the children themselves. The wise teachers knows, and follows, the policies of the school district, adjusting projects and expectations to match limitations imposed for the sake of safety.

**Plagiarism & Copyright violations**

This is an enormous problem. Once they learn about command-copy, command-paste, students are quick to figure out that the Internet can save them an enormous amount of thinking and writing time. Not only do students freely copy text for reports and essays, they freely copy images. The doctrine of Fair Use allows students, and teachers, to use copyrighted materials (which would be everything created in the last 78 years or more!) for educational purposes, as long as citation is given correctly and content and use restraints are followed. As you are no doubt aware, a "special case" exists for P2P sharing of software, digital audio (mp3) and video files, where there is clear violation of copyright by the act of downloading.

Teachers must learn about Fair Use and copyright and teach students about it—as soon as students begin to use the Internet for academic purposes. You will hear this message throughout this text, and it will explored in the next chapter in terms of multimedia, but you might at this time glance at the materials found at these resources:

- Purdue University has created a terrific guide for Avoiding Plagiarism ([http://owl.english.purdue.edu/owl/resource/589/01/](http://owl.english.purdue.edu/owl/resource/589/01/))
- TechLearning's Copyright Guidelines for Administrator's ([http://www.techlearning.com/copyrightguide/](http://www.techlearning.com/copyrightguide/)) is also useful for teachers
Chapter 8: E-Learning and Information Literacy

The best way for a teacher to avoid student plagiarism is to create assignments that do not encourage it. Structuring such an assignment is not difficult, but it does require a shift in methodology. In general, it is most difficult to plagiarize when the assignment:

- has a creative, multimedia, or an authentic product;
- is largely done in class or has steps and elements that can be closely guided and frequently checked by the teacher;
- requires problem-solving or critical thinking;
- is collaborative or cooperative;
- follows a guided research model, such as The Big Six (http://www.big6.com/);
- is structured to insure that students will be able to read and understand the information they locate.

The best ally for the teacher in all aspects of Internet use is the school librarian, who has been trained in Information Literacy education. The second best allies are the network administrator (the IT guy) and the Principal, both of whom will have to be involved in cases of student abuse of the AUP.

Other problems with Internet use

COPPA (Children's Online Privacy Protection Act of 1998) requires that websites that are visited by children under the age of 13 post a privacy policy that details any personal information collected from those children. In addition, each must contain a way for parental consent to be collected before information can be collected from children. Information would include full names, school name and grade, e-mail addresses, address, and phone number. Basically, this means that if you teach children under 13, you should not allow them to complete online forms without first obtaining the required parent permission as specified by the site. If the site does not specify permission, you should not use it. An excellent and well-written guide to this and other child safety issues is available from CSRUI (http://csriu.org/onedocs/pdf/srui/sruilisting.html).

Ensuring Privacy on the Internet PGP (Pretty Good Privacy) is recognized as the best example of encryption software for ensuring the privacy of personal files or e-mail. Encryption is the process whereby data are converted into meaningless symbols which can only be understood by some party who has the key to decrypt the message back to regular text. This party would, of course, be the person or persons to whom you would be sending the private message anyway. In other words, using PGP, you would set up the system so that the sender and receiver of the encrypted mailings shared each other's keys.

It is beyond the scope of this book to explain how to use the PGP system. The author has prepared a set of tutorials which help the user download a free copy of PGP along with directions on its use. The tutorials are available at http://www.pitt.edu/~poole/PGPintro.htm.

20 As of this writing, there is an unresolved discussion of whether the role of teacher as "surrogate parent" allows for the teacher to give permission for the completion of forms used in the classroom.
Chapter 8: E-Learning and Information Literacy

**Cyberbullying** According to [www.cyberbully.org](http://www.cyberbully.org), "Cyberbullying is sending or posting harmful or cruel text or images using the Internet or other digital communication devices." [cyberbully.org](http://www.cyberbully.org) is devoted to mobilizing educators, parents, students, and others to combat online social cruelty. For more information, check out [http://www.cyberbullying.ca/](http://www.cyberbullying.ca/) and [http://www.cyberbullying.us/](http://www.cyberbullying.us/). Read about how schools and parents in Fort Myers and Cape Coral, Florida, are confronting the real dangers posed by cyberbullying in their midst.

**Online predators** Here's what [Donna Rice Hughes](http://www.protectkids.com/index.html) has to say about this problem facing children today: "One of the attractions of the Internet is the anonymity of the user, and this is why it can be so dangerous. A child doesn't always know with whom he or she is interacting. Children may think they know, but unless it's a school friend or a relative, they really can't be sure. Often we think of pedophiles as having access to children out on the playground and other places, but because of the way the Internet works, children can actually be interacting on their home computers with adults who pretend to be children." Visit Donna's website at [http://www.protectkids.com/index.html](http://www.protectkids.com/index.html) to learn more about this and other dangers faced by children online.

**Cybercrime** ([http://www.cybercrime.gov](http://www.cybercrime.gov))—Stalking, cyberbullying, child abusers who use chat rooms, threatening statements and harassment are all cybercrimes of various degrees of seriousness. The U.S. Department of Justice maintains a clearinghouse of cybercrime information and resources. You will find there legal and policy issues, the U.S. federal code as it relates to this subject, telephone numbers to report the different types of computer crimes, a section for kids, and more. The Internet—Know Before You Go ([http://www.cybercrime.gov/rules/kidinternet.htm](http://www.cybercrime.gov/rules/kidinternet.htm)) is an excellent site to visit with students. Teachers wishing to know more about the serious, and growing, problem of cyberbullying should visit Nancy Willard's site, [http://cyberbully.org/](http://cyberbully.org/).

**Viruses**—Few of the software filtering solutions listed in this chapter will prevent student researchers from acquiring and spreading viruses. This is generally going to be through e-mail activities associated (one would hope) with e-Learning activities, but can also be by file sharing (including files brought to school on portable disks and disk drives). The worst-case scenario, one that happens not infrequently, is the destruction of files stored on the hard drive.

It is generally the responsibility of the IT department to make sure that there is a system-wide solution to preventing the spread of computer viruses. However, teachers with stand-alone or modem-connected computers in the classroom may need to install virus-protection/detection/repair software, sooner rather than later!21

**Garbage**—not objectionable material, just useless content, which leads to a whole lot of wasted time. Again we come back to the importance of the teacher – well-designed and well-planned e-Learning projects minimize the time wasted with (often very appealing) garbage.

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SAVVY SEARCHING OF THE WEB

There’s a rule of thumb which applies to many situations in life. 80% of people use only 20% of the skills they’re capable of. This is probably true as regards searching the Web; most people do it on a haphazard basis.

To find out if you are amongst the 20% of skilled or savvy Web searchers, read the author’s series of articles on this topic published on the Web at EducationWorld.com.

Poole, Bernard J, Cara Bafile. “Searching with Savvy, Part 1: The Best Search Engines.” Published online at: http://www.educationworld.com/a_tech/tech/tech222.shtml

Poole, Bernard J. “Searching with Savvy, Part 2: Web Search 101.” Published online at: http://www.educationworld.com/a_tech/tech/tech223.shtml


LOOKING BACK

This chapter has examined teaching from an almost futuristic perspective. It is true that there are some elementary and secondary schools where students are already routinely using communications media for distance learning. In the majority of schools, however, students are still barely communicating amongst each other, let alone between classes and between schools, across age groups and across cultures. But this is where education is headed as our world shrinks to village-like proportions and as online environments for learning are made available in the schools. The resources available on the World Wide Web are too rich to ignore, as are the opportunities for personal and intellectual growth to be gained from collaboration with other students in and out of the classroom. The hope is that the material in this chapter has encouraged you to learn more about distance learning and the Internet so that you will be able to make informed decisions about using these technologies in your future classrooms.

LOOKING FORWARD

It is fair to say that teachers today have much going for them. Teacher-pupil ratios are better than ever, education is beginning to be recognized for its central role in preparing children for the Information Society, and the very fabric of education is changing as technologies such as C&C take hold. Computers and related technologies are also transforming the traditional concept of multimedia. Teachers are beginning to have available to them a wide range of digital media tools for teaching. Given time and training, teachers will learn how to incorporate these new tools into the way they teach, and into the way students learn.

In the next chapter we will examine the Internet again, this time in terms of the riches it makes available to the teacher, and how best to use these riches to improve education. Chapter 10 will examine the concept of multimedia, along with the equipment that makes up a modern computer-based "smart classroom".
Chapter Nine
Educational Multimedia

I hear and I forget. I see and I remember. I do and I understand.  
Chinese proverb

The Medium is the Message.  
Marshall McLuhan (1911-1980)

Affective learning is Effective learning.  
Bernard John Poole (1943-)

LEARNING OUTCOMES

The term "multimedia" has been used since the early 1960s to describe audiovisual aids (AVAs). The modern interpretation of the term includes a rich set of computer-based AVAs, such as scanners/digitizers, CD-ROM/DVD drives, and digital cameras, along with online resources such as the World Wide Web. These AVAs require computers to coordinate their incorporation into teaching and learning activities, transforming AVAs into AV/IT systems.

In this chapter we will examine all aspects of the modern concept of multimedia, including the following topics.

• Introduction
  • The importance of the senses in learning
  • AV/IT—AVAs go hi-Tech

• The concept of computer-based multimedia
  • Multimedia has added a new dimension to the process of teaching and learning
  • Multimedia authoring tools

• Multimedia Hardware
  • Data capture devices
  • Data storage technology
  • Data display devices

• Software for Media Object Production
  • Audio input
  • Digital image input
Chapter 9: Educational Multimedia

- Output to CD/DVD
- Organizing Media Objects
- Multimedia Courseware
  - Hypertext
  - Hypermedia
  - Hypermedia and the Internet
  - Media Literacy
- Using copyrighted materials
  - FairUse
  - Some Solutions for Schools
- Models

INTRODUCTION

A medium is "an intervening agency, means, or instrument by which something is conveyed or accomplished." (Webster's, 1991). The plural form of medium is media which, in the context of education, includes the means to create, store and present instructional content. These include tools, such as chalk and talk, books and computers, slide projectors, video projection, overhead projectors, document cameras, audio systems (a CD player, radio), combined sound and video systems (television, digital video cameras, and DVD's), and the media objects themselves.\(^1\)

The term multimedia was introduced in the 1960s to describe the combined use of several media, such as text, film, video, still images, and audio. Today, multimedia has become closely associated with instruction that includes the computer-based technologies that are the subject of this chapter.

The Importance of the Senses in Learning

You will notice that all of the media mentioned above target either the eye or the ear. Of the five human senses, vision is recognized as the most powerful data-acquisition device for the brain. Edward Tufte (1990), a professor of statistics and graphic design at Yale University, explains why the most effective presentation methodologies attempt to convey information visually, rather than verbally alone. "Visual displays of information," he says, "encourage a diversity of individual viewer styles and rates of editing, personalizing, reasoning, and understanding. Unlike speech," Tufte says, "visual displays are simultaneously a wideband and a perceiver-controllable channel."

The terms wideband and channel come from the science of communications. The term channel in this context is the same as medium, pathway or route, along which data travel. A wideband channel carries more data at higher speeds. A visual display is an example of a wideband channel,

\(^1\) Also known as a visual presenter or visualizer. We will further discuss this device later in the chapter.

\(^2\) You might remember from chapter 5 that a "learning object" is a snippet of data or information that can be shared and recycled in multiple formats.
Chapter 9: Educational Multimedia

carrying more data at higher speeds than simple speech. A visual display is also "perceiver-controllable" in that the person doing the viewing can absorb the data by scanning them at a speed and in a sequence that most naturally fits that person's intellectual strengths. Howard Gardner (1989), in keeping with his theory of multiple intelligences, would agree that each individual assimilates knowledge differently depending on the makeup of his or her mind.

Speech, on the other hand, though it is a powerful medium for communication when used by skilled speakers, is not so easy to digest. It requires more mental effort to assimilate because less information is conveyed at a slower speed, thus requiring more concentration and extrapolation on the part of the listener. Using words to describe a house will take a lot longer and almost certainly will be less effective than showing a diagram or some photos. This is not to say that a verbal description may not be more beautiful. Paradoxically enough, when the writer or storyteller has great skill with words it often is.

Of course, the senses of touch, smell and taste are powerful learning media, too. The signals that are transmitted to the brain by the touch of a snake's skin will quickly dispel misconceptions of sliminess usually associated with a purely visual experience of these beautiful creatures. This is why good teachers intersperse speech with illustrations and mix verbal presentations with active, hands-on learning. The younger the audience, of course, the more important these sensory vehicles for learning are. This is also one of the reasons for the development of websites and computer applications that simulate experiences—field trips, archaeological digs, scientific experiments, life in the past. These create virtual "hands-on" learning opportunities for many students as well as providing visual and audio instruction.

In our world, "media" has another meaning, of course. Two centuries ago, the term media was first applied to newspapers (Webster's, 1991). By the 1920s, it had come to be used as a singular noun to describe any means of mass communication and advertising. This is the generally accepted meaning of media today. Indeed, to the average citizen, media means "mass media"—television, movies, radio, newspapers, magazines, the Internet, all of which are used more often than not for entertainment rather than education.

However, the impact of mass media upon the lifestyle decisions, the ethical, political, and purchasing choices made by "the masses," and especially by children, has not gone unnoticed by education. It is precisely because of the powerful appeal of mass media, and their success as communication media, that educators are faced with a new paradox: the media that most threaten the values of the traditional classroom are proving to be highly successful when used as educational tools.

This is clearly stated in Why Media Literacy Matters, a position paper from the MediaChannel (Dichter, 2004):

The digital age is transforming the quantity, range, and speed of information and communication in our lives. The mass media affect how we perceive and understand the world and people around us, from what we wear, eat and buy to how we relate to ourselves and others. In the 21st century, the ability to interpret and create media is a form of literacy as basic as reading and writing.
Harnessing the mass media, in all of its forms, for the purpose of improving the education of children has always been an important focus of alert teachers in alert schools. This is not an easy task, for the very tools that do powerful good can do powerful damage when their use is unguided, unstructured, inappropriate, or uncritical. The Internet is now the most powerful media pipeline – and by far the most difficult to regulate. That is why the teacher must continue to teach—and to learn.

AV/IT—AVAs go hi-Tech

The term "Audio-Visual" implies that such teaching aids are only audio or visual. But AVAs, of course, also include the sensory tools of touch, taste, and smell to promote learning. Many chemistry, physics, or biology experiments are good examples of low-tech AVAs that are accompanied by interesting other-sensory experiences considered crucial to the success of a lesson. In addition to low-tech AVA, technology in the form of electronic media has been part of the classroom for decades. Dramatic re-enactment and the use of samples ("show and tell" for example) have always been part and parcel of a good teacher's box of pedagogical tricks designed to arouse curiosity in young minds.

In other words, affective learning is effective learning; children learn most effectively when their minds are engaged, when they feel emotionally involved with what they are trying to learn.

All teachers recognize the advantage of using available technologies to this end, but few teachers have the luxury of exclusive use of stand-alone electronic media players, such as DVD players and monitors on wheels, let alone "smart classrooms" that include online computers, flat-screen monitors, LCD projectors, scanners, digital cameras and so forth. Some schools have personnel whose job it is to take care of AVA equipment, coordinate its use, make sure it is where it should be as per the schedule, and return it to the AVA center after it has been used. Other schools have centralized AV into a library "media center" to which classes travel at a scheduled time. Most teachers have to make do with what is available and, often, to fend for themselves.

Usually, a great deal of planning and coordination is involved in using AVAs. If special equipment is required, forward planning is necessary and the equipment must be reserved ahead of time before it can be integrated into lesson plans. Assuming the equipment is in working order when it is scheduled to be used, it must be set up before class begins, and disassembled and returned at the end of class in case other teachers have scheduled use of the same equipment. On top of this, the teacher must spend considerable time planning the lesson itself, either reviewing, selecting and organizing multimedia content, or creating original multimedia materials.

This is all very well if one is teaching three or four 40-minute classes a day (no more than two if the school is on a block schedule). But most K-12 teachers are lucky if they have one free, so-called "planning" period, each day ("planning" is often a euphemism for "recovery"). Under such circumstances it is understandable that there is no stampede to plan lessons around multimedia in view of the logistical problems involved. Indeed, rather than plan lessons at all, teachers sometimes arrange for the showing of this or that video with the objective of filling time for which

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3 Remember that the radio, reel-to-reel film, and film strip are electronic technologies.
4 Often integrated with the Library.
they have been unable to adequately plan! Other teachers, by default, rely on a predominance of verbal presentation of subject matter, with the chalkboard (or whiteboard) as the medium of choice.

This is not to disparage the chalkboard. As a free-form, ad hoc visual aid it takes some beating and will continue to be a feature of classrooms for some time to come—at least until computerized equivalents of the chalk board, such as the SmartBoard, become the rule rather than the exception. Mocsny (1987) reminds us just how versatile a teaching tool the chalkboard is. "Walk into any [classroom]," he says, "and observe the chalkboard. Less than half the scribblings can be represented directly by ASCII characters. Instead, one sees a freewheeling set of sketches, graphs, equations, symbols, arrows, etc. The skilled instructor throws it all up there while conducting a [class]."

The chalkboard is thus unlikely to be replaced by technology. But it has been improved by technology. Electronic chalkboards (SmartBoards), now commonly used in business environments, simultaneously accommodate both free form, hand-drawn text and graphics and projected content (Fig. 9.1).

Fig. 9.1 Portable and wall-mounted SmartBoards

SmartBoards also have the added feature that the user (teacher or student) can download a "snapshot" of the contents to a printer or archive it as a digital document. This is an example of a media object.

The computer, because of its ability to "talk to" stand-alone electronic AVAs such as televisions, cameras, and laboratory equipment, is transforming AVA into AV/IT (audio-visual instructional technology), a more hi-tech and computer-centric term embracing all multimedia technologies and applications. By both centralizing control and, increasingly, centralizing digital content, the computer makes it possible to teach and learn with multimedia—without the fuss. As argued in previous chapters, the Internet is itself becoming a significant multimedia tool because of its scope, currency, and ease of accessibility both in and out of the classroom. AV/IT centers, whether smart classrooms, e-Learning classrooms, or classrooms-on-wheels, are increasingly

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5 You may recall that ASCII (the American Standard Code for Information Interchange) is a system for representing characters (text and other symbols) in the 1s and 0s of computer language so that they can be stored inside the machine. Appendix A lists the complete set of codes.
central to new teaching and learning models. Teachers who have had the opportunity to use a multimedia system in the classroom, with online access to globally-available media and the hardware and software to create something new with this media, have quickly recognized what an empowering tool computer-based technology is, as much for themselves as for their students.

There will continue to be an important premium placed on careful lesson preparation, of course. Good teachers welcome any technology that helps them incorporate intellectually stimulating interactive multimedia material into their lessons. Teachers are finding that computer-based multimedia, whether online or not, can help them respond even to ad hoc reactions from, and spur of the moment interactions with, their students. More to the point, teachers are discovering that their students are able to work on multimedia projects by themselves.

As any teacher knows, the best way to learn a skill or concept is to teach it to others. Using the same logic, the best way for students to learn is by having the opportunity to teach, including the preparation of multimedia materials so that they can make presentations to their classmates. Added into this equation are the multimedia tools many students now carry in their pockets – cell phones – and the time the average students spends with media outside of the classroom (an average of 6.5 hours a day!) and it is clear that education must take a multimedia turn.

Teachers are getting the message. If they are given a realistic opportunity to use multimedia in the classroom, they are doing so. In the ensuing sections we will examine why this is the case. We will begin by discussing computer-based multimedia, the plusses and some of the cautions inherent in its use. Then we will examine the basic components of multimedia systems. After that, we will look at the concept of hypermedia, which combines multimedia with hypertext for nonlinear data access and presentation – a concept that is embedded in today’s world. Finally, we will look briefly at some model schools and school programs that are experimenting with technology-rich learning environments.

THE CONCEPT OF COMPUTER-BASED MULTIMEDIA

Teachers have always employed many means to capture children’s attention and thus promote learning. As such, multimedia, interpreted broadly, is nothing new. Yet, in general, we rely on very basic tools to express the ideas conceived in the brain. As Wurman (1989) observed: "There are only three means of description available to us—words, pictures, and numbers. The palette is limited. Generally the best instructions rely on all three, but in any instance one should predominate, while the other two serve and extend. The key to giving good instructions is to choose the appropriate means."

In the classroom, teachers and students alike rely on words, pictures and numbers to convey ideas. These are the basic tools of intellectual conversation. But there are many ways in which words, pictures and numbers can be conveyed and many ways in which they can be supplemented and supported. The concept of multimedia encapsulates these many ways—video, still images, text and sound—in which words, pictures and numbers can be delivered for the purpose of conveying meaning. The concept also encapsulates the technologies used to store, edit, project, and transmit the data that are the raw material of meaning.
Chapter 9: Educational Multimedia

Multimedia Has Added a New Dimension to the Process of Teaching and Learning

Multimedia has allowed educators philosophically to escape the concept of education as a regimented experience, just as C&C, the Internet and e-Learning, which we studied in previous chapters, have allowed educators philosophically to escape the concept of the closed classroom. Students who are given access to multimedia courseware, whether as individuals or in groups, can take control of their own learning, constructing knowledge at a pace and in a direction that suits their needs and desires.

Otts, et al (2004) express this idea in compelling terms when they write:

The MTV generation quickly loses interest in math topics presented on the chalkboard by some old fuddy-duddy 60's fossil lecturing about polynomials and rational numbers. A step forward is the use of the overhead projector, but students require even greater stimuli to hold their attention. Use of multimedia brings teaching methods into the 21st Century and helps students catch the dream of success in the 90's and beyond. Multimedia offers avenues for presenting material not possible with other methods, such as: (1) interaction, (2) animation to demonstrate concepts, (3) sound cues, (4) incorporation of stimulating visual effects such as flashing, and (5) nonlinear progression. New capabilities allow teacher-made [presentations] to be accessed via the internet, allowing students the opportunity to study at home.

The use of multimedia software applications is not new. Arithmetic and reading applications, for example, became available as soon as the PC and the Apple could support the level of video and audio required. Reader Rabbit and Math Blaster were two highly successful early learning multimedia applications. Today's computers, including laptops, can all support the multimedia educational applications available on DVD, some of which we highlighted in Chapter 6; smaller and more portable devices are becoming more able to do so with every generation. All subject areas have been enriched by multimedia, and in some academic areas, notably science, multimedia DVDs are replacing texts.

Multimedia, of course, can also be created. For the most part, as pointed out in Bruder (1991), "homegrown approaches in classrooms around the country have become the unofficial testing ground for multimedia—with positive results. Stories abound of ultra-motivated students and rejuvenated teachers working interactively, manipulating and creating projects, [and] producing concrete examples of things they have learned."

Additionally, multimedia has made great inroads into making it possible for students with assistive needs and disabilities to learn with technology. For some, the audio or visual component of a text or learning unit is the only possible means of instruction, drill, practice, or tutorial.

Multimedia Authoring Tools

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6 Multimedia as a learning environment includes the thousands of educational software subsumed under the title of CAI (discussed in chapter 6).
7 This required the development of RAM memory and affordable digital video and audio cards.
8 As has been noted elsewhere, the CD is being replaced by the DVD, which has a much larger storage capacity.
Chapter 9: Educational Multimedia

Coordinating the graphics, video, animation, text, speech, and sound in the development of a multimedia presentation is complex. For this reason, authoring software has been developed to assist students and teachers in this task. Authoring tools that are common in educational circles are Microsoft's PowerPoint, Roger Wagner Studio's HyperStudio™, KidPix, and Apple's Keynote and iMovie™. More powerful (and expensive) presentation tools include Adobe-Macromedia's Director, which runs on both Apple and Windows platforms. Adobe also markets a product called Flash, which is a popular tool for including animation in web page design.

In Chapter 11, we will discuss the process of using multimedia courseware to develop presentations and, in that context, we will take a closer look at web page authoring tools. Before we discuss the special value of a growing subset of multimedia called hypermedia, we need to take a look at some of the tools necessary for the creation and viewing of the various media elements of multimedia courseware.

MULTIMEDIA HARDWARE

Today's standard classroom multimedia system includes all the components of a basic computer system—the computer itself, a color monitor, a CD and/or a DVD read/record drive, a printer (which should be high resolution with color capability), speakers (internal or external), a headset, a mouse (or equivalent), and a keyboard or other input device. As we saw in Chapter 7, the digital classroom also has a high-speed connection to the Internet and should have a voice communication system as well.

Multimedia requirements have led to the extension of the basic computer system to include multiple tools for the creation, editing, and playback of multimedia. These technologies are constantly changing as innovation improves on the state-of-the-art. Luckily, hardware has a useful "life" of longer than the six months it takes to improve upon it. But at least you will get some idea of the kinds of tools available to help you teach and, above all, to help your students learn. There are three categories of multimedia hardware:

- data capture devices that are necessary to capture or convert information to the digital format that can be handled by the computer;
- data storage technology that is large enough and fast enough to facilitate easy use of digital material;
- data display devices that are good enough to allow the user to view multimedia material in the most convenient and high quality manner possible.

The following sections provide a closer look at these categories of multimedia hardware.

Data Capture Devices

Scanners Scanners are used to digitize flat (usually paper based) images or text so that they can be stored and manipulated by a computer. Flatbed scanners are most commonly found in

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9 Keynote has replace Presentation in the newest generation of iLife products
classrooms (Fig. 9.2). Fixed "pass-by" scanners and handheld scanners are often used in the library and for security control tasks within a school.

You may recall from an earlier chapter that the digitizing process converts analog data—typically images (pictures, documents, and so on) or sound (speech, music, and so forth)—into the digital 1s and 0s of machine language. It is important to understand why the digitization of data is so valuable to us.

![Flatbed scanner](image)

**Fig. 9.2 A flatbed scanner**

Financial managers like to talk about "leveraging" the value of an investment. They might advise you to make a relatively small investment in this or that stock or venture in the hopes of making a high return. In the same way, we use a lever when we want to use a small amount of effort to move a large object. Leveraging, in other words, helps us get the most out of what we possess, whether it be money, or strength—or data. The fact is that, once data have been captured in digital form, their value can be leveraged more effectively than if they remained undigitized. This warrants further explanation; so perhaps a specific example will make it clear.

A teacher might organize a class project to put together a historical guide to the oldest building in the town. Some images will be already digital—pictures taken by the class and perhaps some archived online. Others will be historical photographs borrowed from the local historical society. The "old way" such old photos were used in publications was by physically pasting them into the text. Often this meant that they had to be cropped to make them fit—and print photos can't be un-cropped. Effectively, the original photos often had to be destroyed. If the students working on the publication decided to move things around, they had to unpaste (unglue!) the photos and hope that they did not regret having cropped them in the first place, and so on, and so forth. Photos and other pictures on paper were thus awkward to work with because they were inflexible.

Now, on the other hand, old printed photos can be scanned into the computer; they become digitized and, as such, they can be duplicated, cropped, restored, moved, enhanced, dubbed, and otherwise manipulated and saved in a myriad of edited versions. The value of the original photos, once digitized, has thus been leveraged in an infinite variety of ways—without
detriment to the originals. The digitized student photos are much more useful because they are in a more flexible format.\(^\text{10}\)

In general, a scanner digitizes a page as if it were a whole image. It makes no attempt to differentiate one part of the page or image from another. Special software on the computer itself is used to manipulate the scanned image, to prepare it for use in a specific project, to organize it in a digital archive, and/or to print it for distribution in hard copy. Specialized attachments for scanners make it possible to easily scan business cards, slides, negatives and transparencies, further increasing the value of this tool to a school. Scanners are generally "bundled" with the required software applications; many imaging applications, such as Photoshop Elements and iPhoto, "talk" directly to most scanners.

Scanners can be used for text as well as for images, a useful tool for the teacher wishing to leverage teaching materials and tests, out of print texts, and news articles. The technology used to do this is called optical character recognition (OCR). OCR software must be installed on the computer accepting the scanner input, where it works with existing software to convert "images" of characters to editable text.

The Library of Congress, along with other libraries and museums, is currently in the process of scanning every image and every page of every book and document in its collections, indexing and storing them in digital form. (This ongoing project is available at the Library of Congress website, \url{http://catalog.loc.gov/}). Digital libraries leverage the already highly valuable knowledge contained in books, and the perhaps more important knowledge contained in photographs, movies, audio recordings, letters, treaties, maps and other primary source material, by making that knowledge easily available over digital media, primarily over the Internet where schools are concerned.

**Audio and video digitizers** Like scanners, these devices convert analog (continuous) sound and video into the digital (discrete) 1s and 0s of machine language so that they can be stored and edited in the computer. Multimedia computers with audio-in capability contain a built-in sound digitizer. Sound, for example, can be recorded in digital form, then cleaned up once it has been digitized by removing unwanted "noise". All that is necessary for this today is a plug-in microphone\(^\text{11}\) and a sound editing application.

If one is using a regular analog video camera, after the recording has been made it can be digitized using a video digitizer. Hardware exists today to convert every format of video (including old movie "reels") to a DV (digital video) format, generally as easily as connecting two replay devices to a digitizer.\(^\text{12}\) One of the main uses of this technology is to create "canned" lessons that combine many short video clips into a single lesson package., something that

\(^{10}\) You might wonder why we are still talking about paper photographs when digital cameras and digital developing to CD are so readily available. It is most likely that a teacher in this scenario will have to deal with both paper and digital images, depending upon the student, the content of the newsletter, and the economics of the school.

\(^{11}\) Many computers have a built-in microphone as well.

\(^{12}\) Many of the new miniDV cameras can be used as digitizers if they have enough memory. Necessary cables are often included.
previously meant running several VCR tapes in sequence. In another use, students are able to use "home movies" and clips from TV shows to enhance their projects, generally with the addition of voice-over narration and titles. Now that televisions are predominantly digital, devices that capture broadcasts in digital form are also becoming more common in student homes. Programming-on-demand has been, for many years, possible for schools through off-air (and after-hours) recording of much educational programming, but digital TV makes it possible for a teacher to download (to DVD or TiVo) an advertisement free broadcast at any time of day, for use at a future time.\footnote{Cable programming is subject to much less scrutiny than public TV broadcasts, in terms of its use in the classroom (Willard, 2002-03).}

**Digital video and still image cameras** Video cameras, or camcorders, are useful for recording events of interest in any subject area. A digital video camera bypasses the conversion process, recording digital data (audio and video) directly onto its own internal memory or onto a removal memory medium. Newer camcorders record in a “high definition” format, which projects better.

Fig. 9.3 A mini-digital video camcorder

Once in the computer, video can be edited, and commentary added along with music. These are tasks once handled by professional video production crews, but the software available today for Macs and PCs makes it a relative snap. Students quickly learn the technical aspects of video editing. The resourceful teacher provides project ideas in the context of which the students can learn.

Today, the digital camera is a ubiquitous tool for capturing still images in a digital form that can be edited in a computer. Fig. 9.4 illustrates a Nikon CoolPix digital camera, which takes still images, but can also capture as much as 4 Gigabytes of video – and export it directly to social video networking sites such as YouTube as a .mov file!

The digital image is captured on internal memory, memory card or memory stick instead of on a roll of film. This picture can then be downloaded immediately (via USB or firewire) for viewing.
or for incorporation into word-processed documents, slide shows, posters, or presentations in general. The pictures stored on the camera can be erased and replaced with other shots without the delay and expense of film processing and developing, generally with "on board" camera tools.

Students and teachers use such a camera for projects which involve the production of printed reports of all kinds and, increasingly, for digital projects of all kinds.

**Electronic instruments** Electronic music is another useful adjunct to a multimedia system, especially if the teacher or one or more of the students in the class has learned to use the piano keyboard, guitar or other electronic instrument. Connecting to the computer via a MIDI\(^{14}\) interface (cable and port), such instruments can be recorded, and even controlled, from the computer. Modern electronic keyboards can be programmed to provide tempo, beat, harmony, timbre, and other musical features that make inexperienced, even untalented, players sound good; modern computer sound cards have a built-in MIDI synthesizer.

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\(^{14}\) Musical Instrument Digital Interface, which is an industry standard
Fig. 9.5 illustrates an inexpensive portable keyboard that can be used in a classroom.

Fig. 9.5 Kurzweil digital Keyboard

In a sense, electronic music keyboards are to music composition and production what a word processor is to writing. A word processor enables one to form words on the page by pressing the appropriate keys on the keyboard. Electronic music keyboards enable the beginner to generate harmonic sound by pressing keys on the keyboard. As a result, learners can more quickly produce presentable, even entertaining, music.

Not surprisingly, virtual keyboards are also readily available, generally as part of a piano teaching application. The same goes for other instruments, such as the guitar. Additionally, inexpensive software, such as Apple's GarageBand, provides a child-friendly composition environment even if the only "electronic instrument" is the hands and voice.

Aside from its uses in musical and technology education, digital music media created in the classroom or computer lab by a student, for his or her own project, has the advantage of being safe from copyright infringement, no small matter when projects are made available to a large audience. We will investigate copyright considerations later in this chapter.

Probes and Microscopes Real-time display of collected data is a powerful AV/IT experience. Imagine, for example, collecting heart-rate data from a physical education fitness class—and displaying class averages and individual results on a monitor for all to see. Imagine also the impact of an elementary school lesson on leaves, or the biological diversity and similarity of hair, which uses a digital microscope to project, and save, "close up views" for the entire class. Teachers who are able to use these inexpensive devices find that they stimulate curiosity and discussion much more than words or text images. Fig. 9.6 shows a temperature sensor that can be used with a laptop computer or a handheld device.

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15 With the popularity of the iPod and similar devices, and the availability of songs and entire albums online, students of course are quick to insert someone else's audio into their projects.
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Data Storage Technology

CD-ROM, DVD These two storage formats appear identical; each is a flat disk identical to a music CD. Both use laser technology to "write" still and full-motion images, text, and audio, including multilingual sound tracks, making them available for integration with other curriculum materials and incorporation into lesson plans. There is a significant increase in storage capability, however. A CD-ROM will hold up to 750MB of data; a DVD will hold up to 17GB, the equivalent of several full-length movies. Today, CD-ROM/DVD+R and RW (Read and Read-Write) drives have replaced the "floppy disk" drive in desktop and laptop computers. DVD is replacing CD as a commercial format. So popular is the DVD format, because it can be displayed on TV monitors, that new digital video cameras record directly to a mini-DVD format and edit the video on-camera, bypassing the need to download video to a computer.

Many texts in math, science and technology come with DVDs containing multimedia resources, and often quizzes and tests, to supplement the printed material. Copyright free CDs of images, photographs, fonts, design templates and audio clips are readily available for purchase and in some subject areas, notably drama and history, there has been significant development of both formats for the delivery of primary source and simulation instructional materials. “Audio CDs” of fiction titles used in education are often available.

One important use of writable CD-ROM and DVD disks has been to create in-house "media object" archives. Such media, when within the bounds of copyright use, can be duplicated and distributed to multiple students, classrooms and schools. In fact, it is often quicker and easier to distribute workshop and lesson files on a teacher-created (or burned) CD than it is to distribute the same files over a network (due to bandwidth – all of those downloads clog the pipe).

Moreover, many teachers have discovered that digital images, in fact, entire Document folders, can be easily archived on CD-ROM, providing a personal, network-free backup of important files.

Portal small storage formats Students and teachers creating multimedia projects in the classroom or computer lab often find that storage of media files becomes a problem. For this reason, many schools have invested in flash drives, inexpensive mini-hard drives that can be worn

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16 More often, you will find DVD-R discs recording around 5GB of data, or two hours of video.
on a lanyard or keychain and connect to the computer via the USB port. (see Fig. 9.7). Also call key drives, flash drives are available in many memory sizes, from about 128MB to over 4GB, with a subsequent variation in cost. At the smallest level, they are accessible to most families, and many students may have their own.

Other schools are investing in portable technologies for image and video storage, such as Compact Flash and Smart Card memory cards that are used in digital cameras. When also used with a plug-and-play card reader (or a card-reading photo printer) these make it possible for many students to share one camera for project development. The relative inexpensiveness and ease-of-use of these portable formats, compared even with the CD or DVD, make them increasingly popular in today's schools.

**External hard and tape drives** Only those teachers who undertake major multimedia projects, such as serious film, a TV station, or video instruction, will need this much data storage. However, it is included here with an important caveat: Never underestimate the amount of storage a multimedia project will require! The most frequent cause of school network failure is "media overload," caused by moving too many large data files through a network at once, as virtually every college and university discovered in the hey-day of Napster. On a smaller scale, many teachers have learned the hard way that the classroom computer's hard drive, the individual student workstation or laptop, or even the computer lab network, is not up to the job of storing files for more than the most simple multimedia project.

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17 This is of concern to many schools and teachers, for personal drives can be used to transfer applications, images, and viruses that do not "belong in school."
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External hard drives are often portable, although not nearly as portable as the technologies listed above. They do, however, store gigabytes of data and connect to the computer via the ultrafast firewire technology, making them useful for multimedia project development as well as backup. Tape drives, which use removable magnetic tapes to store data, are generally used for essential server backups and archiving, for the tapes can be physically stored in a separate location, accessible in case of fire, virus attack or other disaster.

**Computer and Network Storage** For small media files and file distribution, the fastest storage, and sometimes the only storage, is on the classroom computer or student laptop hard drives. As long as the teacher, or a knowledgeable student, remains constantly aware of the memory available on the computer(s), this is a safe system. In fact, most media files, especially large files, should be opened only after moving them off of external storage media and onto a local drive.

The computer network, including the Internet, is a good solution for teachers wishing to make media files, or "learning objects," available to others anytime, anywhere there is an Internet connection. A broadband network connection is recommended, however, because uploading and downloading media files over a dial-up or P2P connection can be painfully slow. Apple's .Mac account, which is actually storage space on a remote computer, is one example of the inexpensive commercial solutions to media storage. Networked schools generally make storage space available to students and teachers on the school's data server, which in some cases can be accessed from home.

Free storage space is also now available online. Many of the social networking and Web 2.0 sites store video, audio and image files, up to a set limit, free of charge. Teachers who make use of accounts on these spaces, Flickr for example, leverage the Internet in a new way – by sharing their images, they gain access to millions of images shared by others. As discussed in Chapter 8, this elevates an image library to a possible e-Learning experience, for social networking sites exist for sharing and Commentary – powerful tools for learning. It also requires supervision, parent education (and often permission), and IT approval!

**Data Display Devices**

**Projection systems** Often there will be situations where the computer is used to display material to a large class group. A teacher may want to demonstrate software, or display data sets, or display graphics developed from data sets, or display work such as word processing which is the product of group collaboration. In such situations, the small size of the computer screen makes it impractical for working with more than one or two students at a time.

For whole class multimedia presentations it is useful to have in the classroom a large screen along with video projection. Ideally the LCD (liquid crystal display) or DLP (digital light processing) projector, to which a computer or other digital hardware can be connected, will be ceiling-

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18 “Pro” accounts are often available for a fee – with no advertising, more storage, enhanced media tools, and often security for educational accounts. They should always be considered by the teacher.

19 Some laboratories have installed on each computer a "monitor monitoring" application, such as NetOpSchool or Show and Tell, that allows the teacher to project one desktop to all stations.

20 These projectors use radically different technologies. A 3rd technology, silicone-based, is being developed. Read more about them at [http://www.projectorcentral.com/lcd_dlp.htm](http://www.projectorcentral.com/lcd_dlp.htm).
mounted. This way, the projection is unlikely to be blocked by student or teacher movement around the classroom. Cords and cables are safely tucked away in the walls and ceiling and the expensive projection equipment is also safely out of the way. Fig. 9.8 illustrates a typical installation for a ceiling-mounted projector.

![Ceiling-mounted projector](image)

**Fig. 9.8 Ceiling-mounted projector**

In a truly "smart" classroom, all devices that can be projected (slide projectors, DVD/CD-ROM, computer, document camera, TV, videocams, laptop) are controlled from a central podium, which functions much like a kiosk to give the instructor control over the media he or she elects to display. A universal remote control, or individual remotes, allows the instructor – student or teacher – to stand at the screen or move around the room.

A digital projector can also be set up on a cart or a desk (Fig. 9.9).

![Projector set up on a desktop](image)

**Fig. 9.9 Projector set up on a desktop**

This has the advantage of portability. The projector can be taken on the road for presentations at conferences and so forth, or moved from class to class within a school building as the need arises. Portable projectors are less expensive. They have the added advantage of being "plug-and-play,"
allowing teachers with laptop-using students to easily show presentations directly from their personal laptops.

**Visual Presenters/Document Cameras** Devices such as that illustrated in Fig. 9.10 are excellent, in combination with a projector (which may be part of the device), for the display of a wide range of three dimensional objects, as well as transparencies and paper-based text or graphics.

![Fig. 9.10 Sony's DC-13 document camera connected to the ceiling-mounted projector](image)

Everything from a Palm pilot training session to a lesson based upon maps, plants, or artwork can be enriched by projection, rather than hampered by the need to pass the visual display around the room.

**Large screen, high resolution color monitors** In a 1-computer classroom or an instructional computer lab, the monitor is naturally at the heart of a multimedia system. Indeed, one can say that the quality of the monitor affects the quality of the entire system. No matter how powerful the computer is, or how extensive the collection of instructional DVDs, or how super the sound system, if the images displayed on the screen are not large enough or crisp enough, the impact will be impaired.

It is becoming more common in school for there to be a large-screen, flat-panel display (like those used in a home theater) mounted in a highly visible, and highly trafficked, area, such as a central hallway or lunchroom. When available, these monitors display selected content that “shows off” student work, as well as content that informs the school community of news and upcoming events. As these displays come down in price, they may begin to appear in multimedia and smart classrooms as well.

**Touch screen systems** Voice recognition and touch screen systems can motivate students because of the intuitive nature of the interaction. To-date, few applications have been devised that use touch screen in the classroom environment, but this technology, along with voice recognition, is becoming more popular for interactive computer systems in public spaces, businesses and so forth. Cell phones, e-book readers and other mobile devices are using touch screen technology almost exclusively. It is likely that the technology will find increasing application in schools and the home because of the ease of use afforded by touch and speech.

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21 One that does is *Clicker*, a presentation and writing application for early readers.
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One extension of the touch screen is the interactive *SmartBoard*, which enables teachers and students to control and interact with a computer application by manipulating, or "touching," its projected image. This is a wonderful way to make a lesson come alive!

**Speakers** If the quality of the audio output that is built into the computer system that controls the multimedia system is unsatisfactory it is a good idea to add external speakers. This inexpensive enhancement can make an appreciable difference to the quality of the multimedia experience.

**Virtual Reality and Student Controllers** No discussion of the multimedia classroom of the future can be complete without virtual reality headsets and student media controllers, technologies currently on the drawing board. There is no reason for the learning experience to be the same for every student in tomorrow’s classroom. Students will take on the role of explorer, with or without maps. The teacher will guide students to selected materials, engage students individually and form collaborations, observe and assess interactive learning, and develop follow-up instructional strategies. In other words—teach.

Here is a vision of the future developed by Mark S. Valenti (2002), a designer of educational spaces:

> An instructor enters classroom #104. As she does, the identification in her bracelet automatically connects to the Web-based control system, which immediately begins to configure the presentation system, network, and room fixtures to her preferences. By the time she sets her briefcase beside the desk, the surface display on the desk has her parameters set, the class Web site is online, and the lights, window treatments, and sound system are being adapted. Students settle in, adjusting heads-up displays and getting out their wireless pens. The instructor waves her hand over the display on the desk surface and turns to the front wall and to the image that appears there, a three-dimensional representation of [course content]. . . Twenty-two students in seven states scribble on digital tablets. Another forty will access the files within twenty-four hours.

Educational multimedia is thus a central component of the 21st Century school, joining web-based communication systems and e-Learning on center stage.

**SOFTWARE FOR MEDIA OBJECT PRODUCTION**

We will deal in chapter 11 with some key tools that students and teachers can use to create multimedia, hyperlinked projects. Before using these productivity tools, however, the individual media objects must be created, refined, and made compatible with the productivity application. Each media technology has its own set of tools.
Audio input is achieved by one of five means:

- "Ripping" a sound clip from one digital medium (often a CD) for use on another requires a software application designed to isolate a sound track and/or section of the track, copy it, and send it to an editor. QuickTime Pro is one application that can do this; other applications are freely available on the Internet.

- Recording sound with an internal or external microphone requires nothing but a sound card or sound digitizer (which can be a separate device and is also generally built into a computer), an inexpensive microphone, and software to manage the record/save process. Such software often comes preinstalled on multimedia computers and many versions are available free for Internet download.

- MIDI input requires a MIDI-enabled device, such as a guitar or keyboard, and an application that can collect the data stream, display it as a musical score, and save it in the desired format. Band-in-a-Box from PG Music and GarageBand from Apple are two such applications.

- Digital music creation software allows the student, without a MIDI instrument, to create, edit and save audio files simply by manipulating the software's menus or using the keyboard. GarageBand can also do this, as can Finale Notepad.

- Downloading a sound file from the Internet, from a CD or DVD sound archive, or from another computer on the network, requires nothing more than access to the files and an application on the local computer that can play them. Real Audio, Microsoft Media Player and iTunes are the most used media for replay. Today's students and classrooms may include an iPod or similar device for storage and replay of sound objects.

Many productivity applications will do one, if not all, of these tasks. Once saved to the local computer (or other storage media), the audio file must often be edited in some way so that it is compatible with the end product's needs. There is a wide range of applications for this task as well, but look first for editing tools in the input/capture application. A good sound editing tool will: save in multiple formats, allow the user to "crop" the sound, copy/paste sound clips, and add multiple sound tracks (for voice-over-music, for example). Many applications allow users to significantly transform a sound, fun for students but often not necessary.

Digital image input is generally achieved though scanning, direct import of a digital file (from a camera, saving device, or the Internet), or the creation of original "computer art." Few images, icons, WordArt files or drawings are perfect as created or imported. Many, if not all, of them will require some "tweaking," if only to reduce the file size and guarantee compatibility with the production tool of choice. You may remember that tools for the editing and manipulation of digital images were discussed in the Productivity Software sections of Chapters 5 and 6. Of all tools, these are the ones with which the teacher should become most familiar. As is true with sound editors, a good digital image editor must be able to convert files from one format to another (always including .gif and .jpg), crop, and enhance by combining with other graphical elements and text. Most digitizing hardware tools come with a basic image editor.
**Digital video input** is a slightly different can of worms. "Raw" video footage, unless intended for "live" replay (videoconferencing, lecture film, performance video, studio broadcast) generally requires a significant amount of editing. Nothing can be more rewarding than a student video project, but the teacher who undertakes to guide such a learning adventure must have access to video editing software that can be used easily by the students. Whether filmed in-house, ripped from DVD, TV, VCR or other prerecorded footage, or downloaded from an Internet resource, the video will need to be cropped (significantly) and titles and credits will need to be added. Apple's *iMovie* and Microsoft's *MovieMaker* can easily be used by students as young as elementary school. There are many choices for video output format and the best tool allows users to save or export final videos in more than one format (including the memory-saving QuickTime .mov format).

**Output-to-CD/DVD** is accomplished with yet another software tool, generally shipped with the recording or input device in "light" form or included in operating system. Roxio's *Toast* and Apple's *iDVD* are commonly used tools. Teachers use this application to create (or "burn") their own audio, video, and multimedia CDs and DVDs. It can be as simple as copying individual files to an application's "in" window, or as complex as creating a fully indexed and hyperlinked autostart application, complete with menu (read about it below).

**Organizing media objects** can be done the hard way or the easy way. As you know by now, an logical and sensible system of folders-within-folders is an organizational necessity. But applications also exist to further streamline the saving, cross-referencing, and eventual recovery of multimedia. Some of these are web-based, some sit on a server, others reside on the individual computer. Teachers should work with the technical support personnel of the school or district to learn to access and use these timesaving applications.

**HYPERMEDIA SYSTEMS: BRINGING IT ALL TOGETHER**

Goldfarb (1991) describes hypermedia as "the union of two information processing technologies: hypertext and multimedia. Hypertext information is accessed in more than one order. Multimedia information is communicated by more than one means." Hypermedia, then, is media accessed in more than one order, an order controlled by the user. It is this interactivity that makes hypermedia such a powerful tool for teaching and learning.

**Hypertext**

Hypertext is text that has *links*²² embedded within it, forming a web of connected information, rather like the neural network that we call the brain. When we think, we often rely on associations that direct us along a path that represents our train of thought. The more experience and learning we have absorbed in the past, the more associations we are able to draw on—hence the value of education. A hypertext system is designed in a similar way, allowing the reader to jump from one

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²² Short for *hyperlinks*, which are references (words, images) that move the user from one place in a hypertext document to another, or to an outside document or file.
piece of information to another in a semi-random, *nonlinear*\textsuperscript{23}, order. This contrasts with the traditional page-by-page, start-to-finish linear order in which we tend to work our way through a book, a video, or a piece of music.

Early hypertext systems were purely text-based, operating similar to the "search" function found today in web browsers, applications and operating systems. Today, hypertext (sometimes called "clickable text" because the standard cursor changes to a pointer when over a link and the user clicks the mouse to follow it) appears in World Wide Web documents, in many word-processed documents (where it is often called a *bookmark*), and in multimedia presentations of every kind.

*Hypermedia*

In 1987, John Sculley, former CEO of Apple Computer, Inc., had this to say about hypermedia: "Hypermedia ... means that you don't have to follow a predetermined organization scheme when searching for information. Instead, you branch instantly to related facts. The information is eternally cross-referenced, with fact linked to fact, linked to fact" (Goodman, 1987). If you remember the earlier discussion of *social networking*, you will see how far this idea has come – data, information and people are now linked in web-based hypermedia.

The importance of hypermedia to education should not be short changed. In the Internet world, students doing research, or even just surfing, are confronted with a majority of texts that they cannot “read” in the traditional sense. Lacking background knowledge, they must construct this knowledge as they go – or fail to understand, and thus fail to gain knowledge. Hypermedia provides a multidimensional context for content, both in terms of the language (or learning style) of its display and in terms of the interconnectedness of multiple contexts. Teachers who understand this can better design coursework that is, to use an old term, “doable.”

*Client*-side hypermedia are those created for purchase as application courseware by schools or families, or those created by the students and teachers themselves. In this category fall CD-ROM/DVD dictionaries and encyclopedias\textsuperscript{25} and hypermedia texts. The category also contains many "edutainment" games, such as *Civilization*, that can be used to supplement both content and concepts in a learning unit, and DVD-based text/learning software, such as that which now generally ships with commercial textbooks.

It is easy to see why many teachers are eager to find a hypermedia DVD that is appropriate for the classroom, for the content is preselected by a production team and, by the nature of the medium, limited. A good multimedia product will be rich in primary source material, whether it be photographs, audio and visual archives, digitized documents, maps, statistical data or recorded performances, and will provide interpreted information and summations that are consistent with the curriculum. With such a product, students interact with the system, determining for themselves the pathway that they will take through the knowledge base. They can use the note

\textsuperscript{23} Nonlinear means non-sequential or, essentially, random. In principle, the user selects the order in which to access the information or file.

\textsuperscript{24} The *client* in this case is the individual user of the product. Most licensing allows for one user on one computer per CD-ROM.

\textsuperscript{25} These will generally also hyperlink to the Internet when access is available.
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taking tools that often accompany the system to develop projects/presentations of their own, drawing on the audiovisual and textual material to meet their academic needs.

The drawbacks to such materials have been significant enough to slow down product development: quality control is often lacking and the cost of producing (and thereby buying) an excellent product often makes its use in the school, laptop classroom or lab (times 20 or more student users per class!) prohibitive. For this reason, commercial educational hypermedia is often broken into separate CD's by purpose (primary sources, media clips, etc.) and bundled with printed texts (or available for an additional price). As an inevitable result of all of these economics, the Internet rapidly replacing “hard media” in the classroom.

This is not to say that the teacher has to give up hope of using, or developing, hypermedia. All of the presentation tools introduced in this and earlier chapters create hyperlinks and embedded media files of just about every type, and those that do not do so today will do so tomorrow. Remember that making media is often a more powerful education experience than using media! There is more about this in our section on Media Literacy. Additional tools for making hypermedia products will be explored in Chapter 11.

Hypermedia and the Internet

Online and standalone multimedia encyclopedias such as World Book Encyclopedia are examples of hypermedia databases. The user selects an item for study and, in the course of the study, may want to delve more deeply into a related topic with links to a video clip, diagram, photo, and so forth. Following links, the user might be drawn to all kinds of information on a voyage of discovery which, like that of Columbus on his voyage to the Americas, may not end up at the originally intended location, but which, notwithstanding, may well have a happy outcome.

The Internet itself, of course, is the quintessential hypermedia environment. Sculley thought of this hypermedia environment in the context of a standalone desktop computer system. But once the World Wide Web was invented by Tim Berners-Lee in the early 1990s, it wasn't long before users could access a global information network of "eternally cross-referenced data" that went way beyond Sculley's 1987 dreams.

The rise of the Internet, with relatively inexpensive authoring tools that facilitate the distribution of multimedia objects, is attractive for classroom use because it can be endlessly configured and it is free (after, as you learned in Chapter 8, the cost of access). It should be remembered, however, that just about anyone can post a multimedia web page. Students and teachers today, in search of multimedia learning and following hyperlinks, often "surf the web" for information, sailing like Columbus from link to link on grand adventures in uncharted territory—hopefully with a goal in mind. Directing and harnessing these multimedia adventures has become one of the greatest challenges faced by the teacher.

Information Literacy was discussed in Chapter 8. You will remember that it contains three skill elements: searching for information, organizing and sharing information, and constructing learning based upon information found. In is in constructing effective research projects that teachers can

26 Wikipedia (http://www.wikipedia.org/) is perhaps the fastest growing example of such a hyperlinked research goldmine.
guide students through the hypermedia rich Internet. Without such a structure, they will be sidetracked by the allure of the very media that can be the highway to learning.

**Media Literacy**

Multimedia is a powerful medium for teaching and learning, condensed in the hypermedia Internet experience. Wilson (1991) describes the educational value of the myriad dimensions of multimedia when she writes:

> The adults of tomorrow will need to be skilled at accessing, filtering, and managing such multidimensional [multicultural and multi-sensory] information. And they'll need to be able to reflect on it, question it, and customize it for their needs.

To do this well—to succeed in the information age—interpretive skills such as problem-solving, creative thinking, and a sense of open inquiry are becoming more important than ever. As the complexity of life and work compounds and the boundaries blur between the educational process and life beyond school, abilities such as coping with multiple points of view, working with others, and conflict resolution will become ever more central. As educators, we'll have to treat these skills as key educational goals.

By condensing access to multiple media on the Internet, schools are providing students with information and misinformation presented in forms that are often manipulative, rather than educational. Media Literacy is a growing field of study and an instructional approach that seeks to address the skills cited by Wilson. Much like Information Literacy, which is focused up critical analysis of Internet-delivered information, Media Literacy is centered upon the multimedia and mass media content of the student's education and experience. Summarizing Hobbs et al (2003), it is the responsibility of the teacher using media and the Internet in the classroom to:

- not merely view (or listen to) media, but engage students in discussion about the media, and do so from multiple points of view;
- seek out, discuss and question the values and purposes of the creators of the media used in the classroom and found on the Internet;
- not merely create media (although creation is an important part of literacy), but think critically about the impact and use of the different ways in which media can be presented.

Luckily, there are good resources for teachers at all levels who wish to learn more about media literacy. Not surprisingly, these are centered in several websites, one of the most current being CML (Center for Media Literacy), [http://www.medialit.org/](http://www.medialit.org/).

**USING COPYRIGHTED MATERIALS**

It will be useful here to consider again the problem of copyright and Fair Use, which we first discussed in the context of the Internet in Chapter 8. The ready availability of media and media-sharing hardware and software, and the nature of young people, make it essential for the teacher
to be on top of copyright concerns, law, and some solutions for the classroom. Silly as it sounds to your students, they CAN be held legally responsible for copyright infringements! Teachers are even more liable.

**Fair Use**

When scanning or downloading copyrighted text and images in order to incorporate them into presentations or newsletters or other media, schools in the United States are covered, in general, by what is known as the doctrine of "Fair Use." This set of guidelines, enacted by Congress in 1976 and expanded in several amendments to cover multimedia use in schools, sets limits as to the size or scope of media object that can be used by students and teachers, how much it can be transformed, and the legitimate uses to which such copied, ripped or downloaded objects can be put. According to Willard (2002-03), four factors are involved in the Fair Use doctrine:

1. **What is the purpose of using the copyrighted work?** If your use of the material is for the purposes of non-profit teaching, you may not be infringing on copyright as long as you don't abuse factor 3 below.

2. **What is the nature of the copyrighted work?** Copying artistic work of various kinds is usually more legally sensitive than copying instructional material ("factual works"). But teachers are hardly likely to be sued on this account if they act within the constraints of the other three factors of the Fair Use doctrine.

3. **What is the amount of work copied in relation to the copyrighted work as a whole?** If a teacher copies whole chunks of texts—say, several chapters—and, without permission from the author, hands them out to students, this could well be seen as an infringement of copyright. The same "distribution" violation occurs when teachers, or students, post someone else's work (a poem, an image, a song, etc.) to a website where it can be publicly viewed or even downloaded. Software is another case in point. When you copy software, you copy the entire work. Schools which make unlicensed copies of software for use by students are obviously violating the Fair Use doctrine. Each media type has its own Fair Use limit; but the teacher can generally be advised that neither the teacher nor the student should use ALL of any media, except perhaps for a reproduced image.

4. **What effect does the use of the copyrighted work have on the potential market for that work?** Artists, composers, photographers and writers of books or software devote years of effort to their creations. Their work may be their only means of livelihood. If copying undermines that potential, it stands to reason that this would be an infringement of the Fair Use doctrine.

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27 All products of creative effort or individual expression are copyrighted in the United States; no © or registration is required. Works published or created previous to 1923 are in the "public domain" unless copyright has been renewed through republication, sale or other means. Works published from 1923-1963 may be in the public domain if copyright has not been renewed. Authors may choose to place their work in the public domain or grant permission for limited use for education; look for notice to this effect, often labeled as *Creative Commons.*
Chapter 9: Educational Multimedia

Some Suggestions

We will take a more extensive look at this issue of copyright in Chapter 13. For now, remember the four criteria above when judging whether you are “fairly” making “use” of other people’s media and remember always to:

- request permission to use large media files of any type, such as videos or whole songs;
- display copyright information with the image, sound or video file, even if it is in the public domain;
- give proper bibliographic citation for all media used;
- resist the temptation to copy multimedia CD-ROMs, software applications or other purchased or borrowed collections of project media;
- include on the title page of every project an acknowledgement that your work "contains media used under the doctrine of Fair Use";
- encourage students to create their own media or to use that created and freely distributed by others\(^{28}\);
- invest, if possible, in "copyright free" media collections;
- create a multi-school archive of copyright-free media materials or objects;
- develop a web page listing websites where copyright free (to education) media can be downloaded;
- teach students about copyright by informing them about the copyright of their work; get written permission before printing or displaying student work to a website or newsletter.

It is important for teachers to teach their students about copyright, Fair Use and correct citation forms. The ease with which students can now download media from the Internet, over the World Wide Web or P2P connections, has led to serious copyright infringement issues. Furthermore, it becomes plagiarism when students present all or part of the work of another as their own. In addition to teaching about it, modeling correct citation and use of media resources is essential. The teacher who fails to follow Fair Use guidelines is sending a powerful message to students.

MODEL SCHOOLS

Let us conclude this chapter by looking briefly at what happens when teachers are given the time, training, and logistical and technical support to produce “break the mold” schools that incorporate into their curricula the computer-based teaching and learning technologies and methodologies that have been profiled in chapters 4 through 9. The following projects are representative of the many other schools where a serious commitment has been made to integrating the computer into the curriculum.

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\(^{28}\) Local teenage bands are often eager to have their compositions recorded for project and video use.
Chapter 9: Educational Multimedia

**Christian Brothers College High School** in St. Louis, Missouri opened its new AV/IT facility in the fall of 2004. Integral to the design of the physical school are a state of the art audio system and wireless networking. All students have laptops and there is not a single chalkboard in the school. The following describes the standard teaching station:

The old oak teacher’s desks are gone. In their place are bi-level teaching podiums in each classroom that offer audio, video, Internet, phone, and security access, as well as a traditional workspace. Multimedia control is from either a laptop computer (that slips into a docking station) or from a Crestron CT-1000 touch panel embedded in the teaching station surface itself. The Crestron interfaces with a cable-TV connection, a Sony VPL-PX11 LCD projector (to a 72-inch Smart interactive white board that allows access and control of any application projected from a laptop source), a document camera, a Samsung DVD-R, and a VCR. Audio/video sources and the laptop are tied to the in-ceiling loudspeaker system. The A/V components in each classroom are housed in an equipment closet and connected through a conduit connected to the teaching stations. (Cont, 2004)

**The School at Columbia University** is a new k-8 charter school founded by Columbia University. Housed in five floors of a city building, it was designed around technology that can be used seamlessly by its young students. The following excerpt from The School's self-description (2003) explains its vision for use of technology:

...the audiovisual technology employed in each classroom encourages students to demonstrate their understanding of the curricular objectives using various media. As such, the use of technology goes well beyond drill, practice, and rote computing to challenge students to first comprehend curricular concepts and then coherently demonstrate their own understanding. This involves not only comprehension of how one communicates effectively, but also discerning the inherent strengths in specific media chosen for one's message. Such skills are increasingly important in an age that depends heavily on the generation, communication, and processing of information.

Unlike CBC, The School places its AV/IT controls in the hands of students as well as teachers. In place of a central podium, classrooms have a wall-mounted (student height) control panel with push-button control of the various technologies. Like CBC, The School relies upon laptop, rather than desktop technologies, in this case the Apple iBook. They provide an almost 1:1 ratio of laptops to students.

These two programs are too new for there to be valid measurement of the impact of the technology on student learning. However, other programs have provided insights into probable outcomes.

**The WEB Project** is not a school, but a non-profit organization based in Vermont. Dedicated to using multimedia and communication technologies to improve student performance in school and to support the development of problem-solving, critical thinking and reasoning in students in rural Vermont, the project uses online tools to link students to “experts” and mentors. Creative media projects, largely centered upon musical composition and visual arts, are designed and completed by students in collaboration with the online team and other students. The program was selected as
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a Promising Program by the US Department of Education. The following is from the report of the Education Technology Expert Panel (2002) on the WEB Project:

As a result of their participation in the WEB Project, students improve their technology skills as well as their performance in the arts by engaging in discussion with mentor experts. There is greater student engagement in learning tasks when students are using the technology to design and deliver products and performances than when working on traditional classroom projects or assignments. In addition, students exhibited increased time on task.

Moreover, Sherry et al report in their summary of the first three years of the project (2002) that in addition to improvements in student academic motivation and problem-solving skills, teachers learned through their involvement in the program. This learning involved new technology and telecommunication skills, but also new teaching and assessment methodologies and the willingness to accept multimedia projects in the place of traditional reports and essays.

Helen King Middle School in Portland, Maine has embraced the project-based Expeditionary Learning model, which is a New American Schools design. Highlighted by the George Lucas Educational Foundation, the programs is described by Diane Curtis (2004) in this way:

At least twice a year, students, who stay with the same group of teachers for two years -- a practice called "looping" -- undertake 4- to 12-week interdisciplinary projects. Besides incorporating such subjects as art, science, and language arts, the projects include well-considered use of computer technology, which has been enhanced by the decision of the state to provide all Maine seventh and eighth graders with iBook laptop computers.

Not all King Middle School students produce technology-based projects to represent their learning, but all learning outcomes are non-traditional, in the sense that they are not on paper and they are not assessed by testing. Since the school undertook this technology-enabled program, "test scores have shot up -- a major accomplishment for a student population that is 60 percent low-income and 22 percent refugee and that comes to school speaking 28 different languages. Following years of below-average scores on the state achievement test, King students began outscoring the state average in six out of seven subjects in 1999, and they even moved into the top third in some subjects." (Curtis).

These model programs are not yet the rule, for many reasons. Among these are: cost, which is prohibitive for many schools and districts; professional development for teachers, which is costly in both money and time; distrust of the shift in classroom pedagogy from traditional "teacher-centered" to more "student-centered" learning models that focus upon collaboration and inquiry; and distrust of the related shift away from traditional assessment methods, such as benchmark testing, and toward rubric and other authentic assessment methods.

You should know, however, that there are a growing number of large and small resources to help schools move forward with the adoption and integration of new multimedia technologies. We will cover grants and funding options in a later chapter, but you might want to take at look at The George Lucas Educational Foundation (http://www.glef.org), which does not make grants but does disseminate, through a multimedia website, models for effective innovation and resources for teachers and administrators.
LOOKING BACK

This chapter has argued that multimedia, which does NOT remove the need for careful lesson planning, takes much of the hassle out of using AVAs, especially when the teacher has access to a classroom multimedia system. Multimedia CD/DVD and Internet-based programs that replace traditional textbooks are becoming increasingly available to schools and copyright free "media objects" can easily be shared by classrooms, schools and districts.

We have seen that students are increasingly creating multimedia projects and presentations to synthesize and share learning, and that evidence suggests that engaging students in a multimedia representation of learning increases both motivation and learning outcomes.

Model classrooms, schools and school districts worldwide are leading the way for others. We can learn from them by reading about them, by attending conferences where their representatives present feedback from their experience, and by visiting these schools in order to see for ourselves what can be achieved. American education is a sleeping giant that appears to be on the verge of waking up. Let us hope so, for if the giant sleeps too long, it may wake up to a world that has passed it by.

LOOKING FORWARD

In chapters 4 through 10 we have discussed the range of applications of computer-based technology in schools. In chapter 11, we will examine specific ways in which teachers and students, but especially students, can use programming and authoring tools to design and create their own applications for teaching and learning. At various points in earlier chapters we have discussed the idea of "writing to learn." We have also discussed a related concept, that of "teaching to learn"— the best way to learn is to teach, as any teacher knows. So when students create electronic portfolios of learning materials and share them with classmates they are, in effect, teaching themselves and their classmates, too.

But giving computers to students before giving them to teachers is like putting the cart before the horse—it is definitely not the way to foster the best kind of computer use in schools. No matter how sophisticated computer-based learning systems become, children will always need the teacher as director/manager of the learning process. Therefore, teachers must first come to understand and appreciate the impact that computers can make by becoming confident computer users themselves.

Successful applications of computer technology occur in environments where planning and design are supported by leadership at all levels and informed by experience. The best leaders empower their associates. When schools initiate technology projects, those responsible for overseeing the projects should call on all available expertise from the top down; without commitment at all levels, attempts at innovation will fail. As Becker observed in *Technology & Learning*

29 *TECHLearning* (www.techlearning.com), *MultiMedia & Internet @ Schools* (http://www.infotoday.com/MMSchools/default.shtml), and *edutopia online* (http://www.glef.org) are just three of the journals highlighting school use of multimedia.
(November/December 1992), "...people generally forget about a key element to success: "buy in" on the part of teachers and administrators."

The empowerment of those involved at all levels of an organization is a practice promoted in the concept of quality control circles (QCC), long advocated by Dr. W. E. Deming and J. M. Juran (Berger, 1986). The idea behind QCC is that the people with direct hands-on involvement with a project are the ones best placed to monitor and influence the quality of the end product. Deming and Juran's ideas, promulgated during the 1950s, fell on deaf ears in America; however, they found a receptive audience in Japan, when that country was struggling to recover from the devastation of World War II. Twenty years later, Japan was emerging as a leading industrial power. The name of the game was quality brought on by empowerment of the people closest to the production of the end product.

In the case of schools, the end product is the education of students; teachers are closest to the students, so they are in the best position to influence the quality of education with the students' best interests at heart. Teachers therefore must be empowered. They must be given the time, the tools, the training, and all the support they need. Without this empowerment, the teachers cannot be blamed if the schools fail to meet stated educational goals. With it, teachers can make the difference, because they are trained and have the heart to do so. When they are empowered by leadership in these real terms, teachers can use the resources provided by technology to become the facilitators of quality education, putting students in control of their own learning and thus empowering those students in their turn.
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Chapter Ten

Multimedia Authorware - Creating Learning Tools

The most important method of education always has consisted of that in which the pupils were urged to actual performance.

_Thomas Alva Edison (1847-1931)_

It's the software that's hard.

_Michael Crichton (1942- )_

The best way to predict the future is to invent it.

_Alan Kay, father of the GUI_

**LEARNING OUTCOMES**

Trained and experienced teachers would be the best people to create computer applications for use in schools. They have studied education theory and methodology. They have applied what they have learned in the classroom. They understand what will work and what will not when it comes to helping children learn.

However, most practicing teachers have neither the time nor the inclination to get involved in the development of applications software for computer-based learning. This is understandable enough. Planning, designing, and implementing such applications using programming languages such as Java or C++ demands an enormous amount of effort on the part of even technically-skilled and motivated teachers.

Fortunately, for the most part teachers do not need to create their own educational software. General purpose productivity and utility software for word processing, data management, communications, graphics, presentations and so forth are created by companies such as Microsoft, Apple, and Adobe, to name but a few, who employ whole armies of skilled programmers and education consultants. Much of their software has application in schools. Also, companies such as Sunburst, Scholastic, Tom Snyder and Broderbund specialize in the development of software (courseware) for the K-12 education market.

But it is useful for pre-service or in-service teacher to know something of what goes into the planning, design, implementation, and support of software systems. Not only might it help them appreciate the effort involved, but it also will help if and when they either start to develop their own applications using authoring software, or need to advise who are students engaged in similar projects.

In recent years, relatively straightforward development tools called authoring systems have been introduced to simplify the task of constructing learning modules or systems. This chapter will examine some of the better known tools, though it is beyond the scope of this book to teach the
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reader how to use them. Readers whose appetite is whetted by this introduction may want to work their way through the tutorials for PowerPoint which are part of the sets of tutorials for Microsoft Office 2000, Office XP, Office 2003, and Office 2007, which are an optional accompaniment to this text. The tutorials are available free of charge on-line at the following URLs:

Essential Microsoft Office 2000: Tutorials for Teachers
http://www.pitt.edu/~edindex/Officeindex.html

Essential Microsoft Office XP: Tutorials for Teachers
http://www.pitt.edu/~edindex/OfficeindexXP.html

Essential Microsoft Office 2003: Tutorials for Teachers
http://www.pitt.edu/~edindex/Office2003frame.html

Essential Microsoft Office 2007: Tutorials for Teachers

Here is an outline of the topics to be covered in this chapter.

• Introduction: programming is hard
• Why should teachers learn about software development?
• Some historical background on programming languages
• Knowledge is Power
• Characteristics of quality authorware
• Quality Authorware puts the non-technical user's needs first
• Quality Authorware is crafted with care and is relatively bug-free.
• Quality Authorware makes the computer appear to be almost human in its responsiveness and anticipation of user needs
• Quality educational software will eventually have to move to far more powerful computer systems than even those that are state of the art in classrooms today
• Authoring programs: How teachers can get involved
  • Kid Pix Deluxe
  • HyperStudio
  • PowerPoint
  • TK3
• Programming on the Web
  • HTML, JavaScript and JAVA
  • Web page Editors
  • Online Solutions, including blogs and wikis
• Authorware Essentials

INTRODUCTION: PROGRAMMING IS HARD

Teachers k-12 are not expected to develop computer software from the ground up. After all, creating quality software is a tough task for even a professional software engineer. It is accepted in the software development industry that no program is free of errors, or, to put it another way:
"bug-free software is an oxymoron" (Meyer, 1992). Gleick (1992), while noting the importance of the software industry to the American economy, almost in the same breath reminds us that "bugs" are its special curse.

The fact is that programmers are human. The software systems they develop are recognized as the most complex that have ever been built (Olson, 1985). Even what appear to be simple programs such as word processors or spreadsheets may today have several million instructions. Software development is, quite simply, a mammoth undertaking.

A few teachers develop their own educational software from scratch. One such is Donna Mason, a computer education teacher and lab coordinator at the Alice Deal Junior High School in Washington, D.C. When she started teaching at Deal in 1983, there were no computers. When the school did acquire computers, there was no software to run on them, so she developed her own. The system she wrote, MicroWorks, was later published. In 1988, Donna was named a Christa McAuliffe Fellow, and in 1991, she was chosen by Electronic Learning magazine as one of "10 Who Made a Difference" (Electronic Learning, 1991).

But Donna Mason is the exception that proves the rule: teachers for the most part are not programmers. Nor should they be, since computer programming is a full time job of its own. Of course, some teachers who specialize in mathematics or computer studies are not only qualified, but they usually have a natural ability to write the step-by-step instructions that tell a computer what to do. A small percentage of students will also be enthusiastic about programming and might even create useful software applications.

WHY SHOULD TEACHERS LEARN ABOUT SOFTWARE DEVELOPMENT?

Our concern in this chapter is with the majority of teachers. We need to examine to what extent all teachers can be expected to get involved with the development of software and other higher level learning systems such as multimedia applications.

Some Historical Background on Programming Languages

Software development occurs at several levels. Traditionally, programmers talk about low level programming, which uses programming languages (machine language and assembly language) which are close to, or at, the internal machine level of the computer. Low-level programming involves the most detailed and extensive sets of instructions to tell the computer what to do. Such programming is of no concern to the vast majority of teachers.

At a higher level, programming involves the use of languages such as Basic, Pascal, C++, Java or Logo--to name only those most commonly learned in k-12 schools. These are examples of what are known as high level languages (HLLs). They still require some understanding of how the computer works, and they also involve large numbers of instructions to get the computer to do

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1 A "bug" is a small flaw in either code or the structure of a computer program. The word "bug" has been used to describe errors in computer programs ever since Grace Murray Hooper, while working at Harvard on software for one of the early electronic computers, discovered that the problem with her program was caused by a moth that had gotten lodged in one of the switches or relays inside the machine, preventing the switch from flip-flopping on and off. Once she removed the bug, the computer program ran just fine.
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anything particularly worthwhile. But they are closer in syntax and "vocabulary" to human languages.

At another level are object-oriented programming (OOP) languages like RealBasic and VisualBasic. These eliminate some of the difficulties with program structure and "end result interface" by allowing the programmer to use graphical assistants, code snippets and templates; the program is built visually rather than entirely through code.

Probably fewer than about 1% of teachers have ever developed a software application that has more than a few hundred instructions. But many teachers over the last decade, in their efforts to learn about computers, have toyed with programming at this level as part of computer literacy courses—maybe using a language such as html to put together web pages. Perhaps you are one of these teachers, and perhaps your experience has taught you that you are better off leaving this kind of programming to others!

At a still higher level, there are languages such as SQL (Structured Query Language)\(^2\) which were specially designed to simplify access to data in large database management systems (DBMS), and ProLog, which is highly mathematical in structure. These languages are known as very high level languages (VHLLs). Since these languages and their applications are predominantly of use to researchers, corporations, and central educational administrations, it is unlikely that teachers would need to be familiar with them either.

Early multimedia authorware was a bridge between high level languages and today's multimedia authoring tools. Apple's HyperCard and early versions of LCSI's MicroWorlds and Solutions Etcetera's SuperCard, for example, allowed users to create stand-alone applications that included scripted media elements, such as animations, graphics, sounds, and hyperlinks. It was still necessary, however, for users to learn a "language." These applications have not disappeared; in fact, they have become more refined, enabling users to create complex learning environments. The newest generation includes Alan Kay's Squeak, MicroWorlds EX and MicroWorlds JR, and Macromedia's Flash, multimedia problem-solving and programming exploration environments that can be used by students as young as pre-K. These applications are providing web-based collaboration tools for the constructivist learning environment. They have the advantage of being powerful learning tools, but the disadvantage of having a somewhat steep learning curve. They are not tools for casual or "sometimes" use in the classroom.

Luckily, there are applications development tools, such as the authoring tools that we will profile later in this chapter, which require next to no understanding of how the technology goes about its work. Users work from "buttons" and menus and take advantage of the "drag and drop" capabilities of the newest operating systems. The programming happens entirely in the background, thus releasing the "programmer" to concentrate on the application, educational or otherwise, for which the courseware is required.

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\(^2\) You may have run across MySQL, which is a database application used to create web-based forms. In a user-friendly format, it is often provided as a service to clients by webhosting companies.
Examples of these authoring tools are Broderbund's *Kid Pix Deluxe*, Sunburst's *HyperStudio*, Microsoft's *PowerPoint*, Apple's *Keynote*, and Night Kitchen's *TK3*. We will briefly examine each of these applications, along with some authoring tools for the Web.

Teachers and students should learn to use one or more of these tools, or similar tools, so that they can use them for teaching and learning. When the teachers, through their own experience, know the potential of an authoring tool, they can more effectively direct students in designing worthwhile projects that take advantage of the tool's full range of capabilities. Authoring tools provide a discovery-based or constructivist environment for students of all ages to conduct research, gather data, organize their thoughts, think creatively, and share their newfound knowledge with others.

**Knowledge is Power**

Because of this variety of approaches to programming, different teachers will have different reasons for wanting to know how to go about developing software applications. Here is a cross-section of those reasons. It will be interesting for you, the reader, to see where you fit in this spectrum of rationales.

- Programming a computer helps one understand how the computer works, which leads to a greater sense of control when using the computer for more general and pre-packaged applications.
- Knowing how to program a computer helps one appreciate the work that goes into the systems that are used by teachers and students in educational settings.
- If one knows how to use software development programs such as authoring systems, one can develop applications that are tailored to one's specific local needs.
- Students like to develop their own programs/presentations using multimedia tools. If teachers understand how these tools work, they can be a better resource for their students in the classroom.
- Teachers who understand what constitutes a well-developed program will be better at selecting applications that will be effective educational tools.
- Teachers who have survived what might be the trauma of trying to figure out the correct logical sequence of instructions that constitutes a computer program will be sympathetic towards students when they have difficulties with the same process--or any learning process, for that matter.

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3 *Kid Pix* was originally created by Broderbund, which is now a sub-division of Riverdeep. *HyperStudio* was originally created by Roger Wagner, but has since been sold several times. This is not unusual in today's software marketplace.
CHARACTERISTICS OF QUALITY AUTHORWARE

*Quality authorware puts the non-technical user's needs first*

Usability engineering is the application of human factors (also called "ergonomics") to system design. The most time-consuming aspects of software development often have to do with how well the product will fit the "event world" for which it is created (Debons, 1988). The "event world" of K-12 schools is populated by end-users who do not expect to have to learn how a machine operates in order to put it to work.

Key to lay acceptance of computer technology are ergonomic considerations that dictate that the designer of a system understand, and cater for, the cognitive and physical constraints that the human user brings to machines. What Tufte (1990) says about the graphical visualization of information applies equally well to software in general and to educational software in particular. "Clutter and confusion," he says, "are failures of design." The best software applies principles of ergonomics to all aspects of design so that the end product--the program--is as easy as possible to use.

Bailey (1989) notes that "a good computer-based system does not require extensive assistance from people." It should be designed in such a way that it marries into the paradigm of normal, everyday practice: business, educational, or otherwise. This emphasis on usability is a relatively recent phenomenon. Systems in the past that had an unreasonable learning curve associated with their use were successful only because there was little alternative for people who wanted to use the computer to increase productivity and control. Today, however, it is understood that the benefits of advances in technology should be made available to all, not just the privileged few who were able to master the intricacies of traditional systems.

Moreover, as Stahl (1986) explained in his article enunciating the principle of "least astonishment" in interface design, "system performance is directly dependent on user performance." When users are comfortable working with a system, they will be more productive. Some orientation is, of course, inevitable and time must be allocated for this in the introduction of a new system. But as Arthur Young & Co. discovered when they selected Apple's Macintosh as the standard system for their accountants, the adoption of a system that weds functionality to ease of use can bring a convincing bottom line benefit to the organization in terms of reduced end-user support costs and increased end-user productivity (Garfinkel, 1987).

Fortunately, the last few years have seen the industry-wide adoption of standards for the software interface which have greatly simplified interaction between the machine and the people using the machine. We discussed these graphical user interfaces (GUIs) in chapter 3. They require the user to work in the context of *windows* in which they use the mouse to *point* and click on *icons* (pictures that represent processes and files) and select from *menus* or lists of things to do. The *Windows, Icons, Menus and Pointers* that are the components of the GUI give us the acronym *WIMP*, which captures the essence of modern easy-to-use computing environments. Just about all the information needed to know about how to use an application is there in front of the user on
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the screen. Once one application has been learned, the learning curve to master other applications is considerably less steep because the interface is familiar across applications.4 Teachers want to be able to focus on the pedagogical aspects of courseware, not the technological ones. Teachers do not want to have to learn technical material in order to use software, nor do they want to have to teach that technical material to their students. One way to help technically-shy teachers get involved with technology is to introduce them first to systems that are both easy to use and at the same time manifestly useful for some teaching or learning activity.

Quality authorware is crafted with care and is relatively bug-free

It is almost impossible to guarantee that the software one acquires will work as it should all the time. This is because it usually takes hours, days, weeks, even months of use before many bugs show up. In fact, a corollary of Murphy's Law says that bugs show up when least expected and at the worst possible time. For example, you have just about finished typing up a ten-page term paper that you have not yet thought to save. The system freezes up. Yikes! Now what? You may never know if it was the applications software you were using that caused the problem, or some utility program running in the background. Who cares? All your work is gone!

This happens all the time.

It pays to know the reputation of the company that has developed the hardware or software, and the only way to keep track of this is to read reviews that appear in educational journals and to check with colleagues in your own or other schools who have used the technology. You may also be able to run your own test of software by downloading a free demo copy of an application from the producer's website. Such full-functioning trial versions are increasingly available. Another thing to look for is a "beta" version of a new application. These are not guaranteed to be "bug free," but they have passed the first few rounds of serious "alpha" testing. Betas are always free and often very usable.

If you ever develop your own software, or if you are working with students who are developing projects around multimedia systems, the most important recommendation is to pay attention to detail. This attention to detail is the hallmark of the best professionals in all walks of life. The second most important recommendation is to maintain your focus upon an educational outcome. Remember that computer applications are excellent because they are part of an excellent lesson, unit or curriculum. These points together mean that developing software and applications is hard work!

Quality authorware makes the computer appear to be almost human in its responsiveness and anticipation of user needs.

New artificial intelligence (AI) and Fourth Generation languages5 such as those used to create operating systems and authoring software, and better yet, natural language itself, greatly simplify

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4 Assistive technologies and applications that take advantage of them are perhaps the most profound present-day illustration of good design. Applications such as Cricketsofts's Clicker and Intellitool's Classroom Suite meld multimedia and design to make reading and writing assessable to all elementary level students.
human interaction with the machine. *AppleWorks*, for example, along with other integrated software or suites of software such as Microsoft *Office*, are designed in such a way that they know whether a user is involved in word processing, or database management, or another of the productivity functions that come with the package. When the user wants to create a diagram, or import some artwork, the user simply starts working with the graphics tools, and the system handles the switch to that module of the software.

As we will discuss later in this chapter, authoring software make software development relatively intuitive, allowing the developer to focus on the purpose for which the application is intended rather than on the process of development itself.

*Quality authorware will eventually have to move to far more powerful computer systems than even those that are state of the art in classrooms today.*

The paradox is that, in order to optimize the human resource by designing thoroughly ergonomic systems, we must rethink the design of traditional computer architectures so as to improve the performance of the machines. Execution of one instruction at a time, for example, is too slow for the kinds of applications envisaged by researchers in AI.

The processing necessary to allow for the simplest of natural interactions stretches the capabilities of many currently available computing machines. Graphical interfaces have been demonstrated to be among the most natural for the human user, but such interfaces are extremely demanding of machine time and space. Natural language interfaces, too, which allow users to interact with the machine in their own native tongue, apart from presenting enormously intractable linguistic difficulties, are once again very demanding on machine time and space.

The most powerful computer in the world in 1946--the ENIAC\(^6\)--was equivalent to the pocket calculator built in the 1970s. Today's most powerful computers, capable of processing trillions of instructions per second (teraflops\(^7\)), will inexorably become the personal computer of the not-too-distant future. Already the PC is capable of executing billions of instructions per second (gigaflips) and it is just a matter of time before the teraflop barrier is crossed, leading to a quantum leap forward in terms of PC functionality. Moreover, the ongoing increase in processing speed is accompanied by an ongoing increase in portability. Not only will the classrooms of the future have very fast computers; they will have very small and entirely portable computers with seamless, wireless access to the internet.

With such machines in place we will see a world open up which will make the advances made to-date in computer technology seem puny by comparison. Most important of all, these machines will enable the creation of software systems that will help educators realize the full benefits of technology in the classroom, without the kind of mental trauma which has given so many teachers

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\(^5\) A Fourth Generation programming language is a high level language that uses "natural" expressions, such as Process and Print, to encapsulate many lines of code.

\(^6\) The electronic numerical integrator and computer (ENIAC) built by Presper Eckert and John Mauchly, and profiled in Appendix A (The History of Computers).

\(^7\) "Tera-" is the prefix that stands for ten to the twelfth power, or a trillion, just as "giga-" is the prefix for ten to the ninth power, or a billion. So a terabyte is a trillion bytes. "flops" is an acronym for "floating point operations per second." Thus "teraflops" is the word used to describe a trillion instructions per second.
pause up till now. But Michael Crichton's caveat, quoted at the outset of this chapter, will continue to hold true: "It's the software that's hard".

AUTHORING PROGRAMS: HOW TEACHERS CAN GET INVOLVED

Chapters 5 through 10 examined in detail what teachers need to know about computer use in the classroom. In summary, teachers are proficient using technology when they feel comfortable about:

- working in a computerized environment;
- using computer-based tools to manage their professional activities in and out of the classroom;
- incorporating a wide range of computer-based learning into their curricula;
- using computer technology to establish close contact with parents;
- encouraging students to use communications technology to establish cross-cultural links with children and adults around the world;
- incorporating multimedia systems into the learning process.

These technology-proficient teachers will provide their students with an educational environment in which each student's individual and infinitely-varied talents can grow. If, on top of all this, these teachers are able to use, and direct student use of, authoring tools to fashion learning systems that incorporate hypermedia technology, they will have made the transition into the world of Education For an Information Age. This is not as difficult as it sounds. Let us look at some examples of authoring tools.

Traditionally, as explained above, programs are created by programmers. These are usually people with strong technical skills who have undergone extensive training. Authorware are programs which help people who are non-programmers develop applications for the computer. They are a natural outcome of the recognition that the best people to develop software are those who are experts in the area of activity or expertise for which the software is intended. This, indeed, was Bill Atkinson's vision when he developed HyperCard, the first authoring system for microcomputers and the prototype for most of those that have been developed since 1986. As Atkinson put it: HyperCard is "programming for 'the rest of us'." (Goodman, 1987)

People who understand business are the best people to write applications for business. Likewise teachers have considerable expertise and experience related to teaching and learning methodologies. They are, therefore, the best people to be involved in the development of all types of CAI. Indeed, many of the companies that currently develop software for schools were founded by teachers with the technical skills needed to design and develop software. Other companies that specialize in software applications for schools have teachers on their payroll either as full-time personnel or as consultants.  

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8 This is also true for Internet based educational applications.
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Of the many examples of authorware available today, we will profile just four in the sections that follow. First we will profile *Kid Pix Deluxe*, the simplest and easiest to learn and, for these reasons, perhaps the most useful with younger children from a practical point of view. Then we will briefly examine *HyperStudio*, *PowerPoint* and a new application called *TK3*. These authoring tools are designed for both Apple and Windows systems, and are possibly the most versatile of the authoring genre of educational software. We will not be looking closely at *MicroWorlds* because of its programming component, but we urge interested teachers to undertake an investigation of Logo and this powerful learning environment.

**Broderbund's Kid Pix Deluxe**

*Kid Pix* is an interactive drawing program. Unlike COREL’s *CORELDraw* or Adobe *Photoshop*, it is not a highly sophisticated drawing package. But, like Apple's *AppleWorks Paint* module or the Drawing tools in Microsoft *Office*, it is highly effective environment for creating lively, inventive graphics. It has the added advantages of a simple toolkit layout and a set of tools consistent with AppleWorks, Microsoft *Paint* and other basic paint applications. *Kid Pix Deluxe* is a presentation package which includes a new version of *Kid Pix* as well as new tools to take advantage of processor speeds, system capabilities, and larger hard drives. It is useful for creating sound-enhanced slide shows of *Kid Pix* graphics, but it also imports still and movie graphics drawn from an infinite variety of other sources, including any movie that has ever been made, provided it is accessible in a digital format (and cleared for copyright).

As made clear elsewhere in this text, it is not the intention of the authors to advertise any particular product. Consider this a disclaimer to that effect! But *Kid Pix Deluxe* speaks for itself as a remarkably simple, yet powerful, example of authoring software. It should be made available as a learning tool in every elementary school classroom and computer lab. It helps if the classroom has at least five or six computers with CD-ROM/DVDs, so that the children can work in collaborative groups on projects drawn from the curriculum.

**Storyboarding**

Storyboarding is a technique developed in the movie industry. Each storyboard is "a panel or series of panels with sketches depicting changes of action and scene" (Random House, 1991). Adapted for an interactive medium such as the computer, the storyboard can come alive with animations, video clips, and sound. The computerized storyboard can also interact with the user, prompting for responses to situations presented in the storyboard's action.

In *Kid Pix Deluxe* the user can work on any particular project with up to 99 storyboards, each of which is represented by a moving van which can be programmed to “carry” still or moving graphics, sound, text, and transition effects. Buttons on each slide in the storyboard provide access to each of these options (Fig. 10.1 next page). As you examine the illustration, play the role of a pre- or early reading student. After a short lesson, would you be able to make a short presentation?

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9 *IrfanView*, a free paint program for Windows, uses a similar toolbar. This cross-over of tools is an important element of software usability.

10 *Kid Pix Studio* is an earlier, and very similar, version - it may still be available on many school computers.
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- Click on the first button associated with a particular storyboard, and the user is prompted to select a still or moving image to be included with that storyboard. The graphics can be selected from commercial clip art saved as graphic files, *QuickTime*™ movies, or art prepared using a paint program or *Kid Pix* itself (this is where a teacher must be part of the process).

- Click on the second button, and the user can paste in prerecorded sound clips, such as a Martin Luther King speech, or use the microphone to record commentary, either on the fly or, ideally, from a prepared or "live" script.

![Kid Pix Deluxe interactive storyboard showing the function of the buttons](image)

- Click on the third and last button, and the user can select from a set of transition effects which will provide a smooth transition from the current slide to the next. Effects can be previewed.

A resourceful teacher will quickly learn how to use *Kid Pix Deluxe* to prepare learning materials on any subject matter for use in the curriculum. Still more resourceful teachers will show their students how to use this tool so that the students can use it to put together presentations which are the outcomes of individual or group project work.
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Products such as Microsoft’s PowerPoint and Apple’s Keynote have the same storyboarding capability, the only difference being the ease of use with Kid Pix for especially young children.

**Sunburst Technology’s HyperStudio**

Roger Wagner Studio’s HyperStudio was a ground-breaking k-12 application designed with a familiar index card model: "Stacks" contain sets of electronic cards, a format that has not changed in the subsequent versions of the application. Each card can be programmed with buttons, graphics, sounds, text, and other multimedia elements, including media links to the Internet. Many media elements can be created with the application itself, which contains an animator, a sound recorder and a paint program. Many other forms of media can be imported into a card's environment. HyperStudio projects can comprise a single stack, or can be made up of two or more stacks linked together. Like Kid Pix Deluxe, HyperStudio has built-in paint tools for drawing and artwork; like Kid Pix Deluxe’s storyboards, HyperStudio's storyboard provides an overview of the project and links to individual cards, that in turn can hold links to graphics, sound, and so forth. But here the similarity ends.

HyperStudio is a more comprehensive application development package. It allows the user considerable flexibility in the design and content of stacks, limited, for all practical purposes only by the amount of primary and secondary memory available, the speed of the computer's processor, and the developer's time and creative skill. For this reason, it is more difficult to learn and use than Kid Pix Deluxe, largely because there are many more features to become familiar with. But, once learned, it is possible to create rich multimedia learning environments with application at all levels of education, from pre-K through college.

Logo provides a useful extension to HyperStudio. Any card in a stack can be linked to a Logo program. Since Logo effectively can be used to create any application, a HyperStudio stack can contain, quite literally, an infinite range of problem-solving functionality. New versions of HyperStudio enable the user to script directly in HyperLogo, a language very similar to Logo in syntax and vocabulary.

Another advantage to HyperStudio is its support of web-based projects. It is possible to Export stacks as .html and to upload them to web pages, playable on any computer platform with the free HyperStudio Player.

It has to be said, however, that HyperStudio has been now superseded by the more popular presentation programs PowerPoint (for the PC) or Keynote (for the Mac).

**Microsoft's PowerPoint**

PowerPoint is understandably the most-used presentation program. It is part of the Microsoft Office suite of productivity software and therefore is available on well over 90% of computers. It is also the easiest presentation program (along with Keynote) to learn for developing effective presentations, learning modules, and other kiosk-style applications where the goal is to present information to an audience.

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11 If your computers are on a network, you must also consider network bandwidth and the size and configuration of the system storage device. Many HyperStudio projects have been lost because of network weaknesses.
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PowerPoint has many powerful features, but for education perhaps the most powerful features relate to its interactivity. As part of Microsoft’s Office suite, PowerPoint contains all of the editing, commenting and notation features built into Microsoft Word and Excel. Students and teachers can not only author presentations, they can collaborate and peer-edit. This makes it an important model for 21st century authorware.

It is strongly recommended that pre-service and in-service teachers be given the opportunity to learn to use this software since there is a very high likelihood that they will be able to incorporate it into their work with students k-12. Soon, every student will have a personal computer with PowerPoint on board and, as pointed out in chapter 6, PowerPoint can be a powerful tool for project-based learning of various kinds.

Night Kitchen’s TK3

New applications are being developed to take advantage of new Windows and Apple operating systems, which allow for a higher level of media integration "on the fly" and which require computers with larger hard drives and faster processors. TK3 is one such application. Like the previous examples, it is cross-platform and able to import media files in multiple formats. Unlike the other applications highlighted, however, it does not create a hyperlinked "slide show." This application creates an e-Book: a self-contained, interactive multimedia text.

You will remember from previous chapters that there is a trend in Internet and server-based educational software toward the development of "media objects" that can be recycled and freely shared. TK3 makes use of imported media resources, sound, video, image, font and text files, to build a compact "book" upon a template designed by the author. In addition, the application supports internal and external hyperlinking, file merging, and export to a compressed format.

We highlight TK3 because it is (a) free open-source software, and (b) a forward-looking application, tailored to teachers who are comfortable with the media tools highlighted in the previous chapter and eager to develop and distribute their own courseware in a self-contained mode (as opposed to an e-Learning mode).

PROGRAMMING ON THE WEB

We learned in Chapter 7 that the World Wide Web was invented in 1991 by Tim Berners-Lee. He created a language and other standards that enabled anyone to create a presence on the Internet that would be accessible from anywhere in the world. This included corporations (.coms), educational institutions (.edus), non-profit organizations (.orgs), the government (.gov), and everyday individuals. Tim Berners-Lee also set up an organization called the World Wide Web Consortium (http://www.w3.org) which manages the Web, developing new as well as updated standards to help everyone on the Web to get along.

12 Currently, the list of possible computer domains that can be purchased in the US is: .com, .org, .net, .info, .biz, and .us. The .gov domain is reserved for state and federal government, and .edu is generally available only to universities and large non-profits that host their own sites.
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The upshot of Tim Berners-Lee's work is that everyone who so chooses can share themselves with whoever is interested in what they have to share. This is both a scary and an exciting thought. As we noted in Chapter 8, there are lots of odd folks out there—people who have mind sets that may not agree in any way, shape, or form with ours! Of course, to these "odd folks" we may be odd, too. But that's another story... Fact is, everyone has a voice, and Tim Berners-Lee has given all of us a global audience. Good teachers take advantage of this beautifully simple, yet powerful, reality.

The World Wide Web is the single most powerful tool at every teacher's fingertips. The Web puts technology-using teachers in "24-7"—twenty-four hours a day, seven days a week—touch with each (yes, each) of their students and those students' families! This is an awesome fact, and one that might take some time to filter through, and alter, the mindset of the teaching profession as a whole.

Think about it... You are a teacher. You have a class of students of whatever age, and you want them to learn something dictated by the curriculum (which hopefully reflects state or national standards). You know the kids love working with computers, so you create your own personal website and use it as a supplement to what you do with the students in class. You include your own content that will guide your students to the information they must learn in order to attain the academic standards laid down. You also use your website to let your students' parents know what is going on in the class. You spend whatever time it takes to research the web and locate sites that have the content that ties in with the curriculum. If you are unable to find relevant content, you shrug your shoulders and create it yourself!

Whoa! Create it myself? You mean teachers should create web pages which contain the information content that they want their students to learn? Absolutely! Because once you, the skilled 4th grade, or 8th grade, or 12th grade teacher, have created such content and posted it on the web, it is immediately available to other teachers, near to home or around the globe, who can use it with their students, too. The content is also available to parents.

So you get to share your excellence with the world. Think of the many excellent teachers who touch only the students that have a physical presence in their classroom. Think back to your own days in k-12 school. Remember the teachers who touched your life in beautiful ways. You know who they are. Now imagine how they could expand their influence over children and their parents if they use the web to reach that wider audience.

Technology in general and the web in particular thus help teachers duplicate excellence. The Internet gives new meaning to the old adage that teachers touch the future. Well-organized web-using teachers—and there are already many of them out there—are pebbles into the pond of education, which create ripples that reverberate around the world.

**HTML, JavaScript, DHTML, and JAVA**

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13 A "website" is a collection of web pages, hosted on a web server. Think of this as a set of documents inside of a folder, which it is, virtually.

14 Here is just one example: Tom Daccord's *Best of History Web Sites* began in the classroom and has become one of the best links for history teacher's in English-speaking countries - [http://www.besthistorysites.net/](http://www.besthistorysites.net/)
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HTML (Hypertext Markup Language) was developed to standardize all aspects of content creation on the Web. Generally, pages displayed on computers that access the Web have been defined using HTML. HTML is a simplified language, not nearly as difficult to learn as typical programming languages such as C++ or even BASIC. This is because HTML gives the programmer much less direct control over the data that is being processed (distributed) on the Web. In the truest sense, it is not a programming language at all; it is a set of instructions that tells a browser how to display digital content. However, HTML still requires of the program writer a certain rigidity and care for detail that stretches the patience and skills of most folks. For this reason it is unrealistic to expect that more than a tiny minority of teachers will want to develop learning materials using "hard coded" HTML.

JavaScript is a simplified programming language used mainly to provide simple interactivity and "special effects" to web pages. Although it is possible to build scripts from scratch, most webmasters will begin with scripts made freely available online and adapt them to meet specific content and design needs. Similarly to JavaScript, but more adaptive and therefore more powerful, is DHTML, a language that also created small scripts that are embedded in the HTML of a web page. Both languages work well with today's browsers, although JavaScript support is uneven. One important script source is Simply the Best Scripts (http://simplythebest.net/info/dhtminfo.html). With a little initiative, a good plan, and attention to detail, almost anyone can include JavaScripts or DHTML scripts in a web page.

Java is another kettle of fish entirely, a sophisticated programming language with much the same capabilities as C++—a full-blown computer programming language. You have probably run across Java in terms of "applets" loaded on certain web pages— if you look at the Status Bar at the bottom of the browser window, you can "see" them being loaded. These applets are used to create complex animation and interactivity. However, entire websites and stand-alone applications are also developed in Java, which is now the programming language assessed by the Computer AP test.

Why then even talk about HTML, JavaScript, DHTML or Java in the context of teacher-created applications for learning? Apart from anything else, it is good to know more than you need to know in order to do what you need to do. An awareness of what some of the more commonly used HTML "tags" ("instructions" in other programming languages) can come in handy when you want to tweak the contents of a web page or if you want to see how an attractive feature of someone else's web page was put together.

You can view much of the HTML and JavaScript source code for a web page in your browser by choosing the View menu option to view the Source, which is often the .html code that created the

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15 "hard coding" is a term that indicates the programmer is writing the code, in this case HTML, from scratch. As you will see in the next section, it is possible to generate HTML without hard coding a web page.

16 A "script" is a miniprogram, sometimes just a short instruction, that sits inside of the HTML on a web page.

17 These are by no means the only languages and protocols used to create web pages and web page interactivity. Some others which you may meet are: XML, Perl, cgi, PHP, and CSS.
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page you see. This code is, of course, copyrighted by its creator (unless you read otherwise), much as a novel is copyrighted. However, it is OK to copy it for the purpose of learning. If you can understand what the HTML tags are doing, then you can play with them, or tweak them, in order to create the look and feel that you want for your page. In this sense a little knowledge can go a long way in terms of web page design. Of course, a little knowledge can also be a dangerous thing! You don't want to mess with HTML unless you know what you're doing.

Think of it in terms of owning a car. You don't need to know anything about maintaining the car. You can just take it to a garage whenever you need anything done. It'll cost you more, but you won't get your hands dirty. A few folks won't even pump their own gas and instead pay the price of full service. But if you know how to fill the gas tank yourself, and if you know how to change the washer fluid or the wiper blades, or if you know how to jump start your engine when the battery gets drained because you left the lights on... You get the point. A little knowledge can save you a lot of time and money.

It is beyond the scope of this book to go into the details of HTML or other programming languages, but there are many excellent tutorials on-line. Among the best can be found at the following URLs: http://www.w3schools.com/html/default.asp (for learning HTML), http://www.scriptsearch.com/cgi-bin/jump.cgi?ID=3878 (a straightforward introduction to JavaScript) and http://www.w3schools.com/dhtml/default.asp (an introduction to DHTML). Teachers who are interested in blogging and wiki's should also consider pursuing CSS. A tutorial can be found at http://www.w3schools.com/css/css_intro.asp).

Web page Editors

Web page editors make it almost entirely unnecessary for you to know HTML. The best known web page editors today are Microsoft's FrontPage (now replaced in the Office suite of programs by SharePoint Designer) and Netscape's Composer. Another popular editor is Macromedia's Dreamweaver. These tools are designed to help you create web pages with a friendly, WYSIWYG (what you see is what you get) interface. They are like word processors for the Web. As such, they greatly simplify the whole process of working with hypertext (text that is "hotlinked" to other related information on the Web), media and hypermedia (text, images, sound, video that is hotlinked in the same way) in the non-linear environment of the Web. New tools, such as Apple's iWeb, further streamline the process, by providing templates and automatic uploading to compatible web spaces such as Apple's .Mac hosting service.

The web page editors use tool bars and simple point and click steps to create what would otherwise be very tricky objects, such as forms, navigation bars, tables or image maps, let alone hyperlinks. The editors are not difficult to learn how to use. What is difficult and very time-

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18 There are many exceptions to this rule, the most common being pages viewed within frames and pages created with Flash or Shockwave, which are really animation objects instead of coded pages.

19 Changes that you make to copied Source code will not, of course, affect the original page. You can only alter a page on a web server to which you have direct access. One easy way to explore HTML is to create a blog or web page using an online host and "tweak" the template you select. We cover blogging in a later section.

20 Image maps are graphics to which invisible hyperlinks have been applied.
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Consuming is the whole process of creating well designed, well thought out, and well-constructed content.

Once again, it is beyond the scope of this book to go into the details of any particular web page editor. In today's teacher training or inservice workshop schedule, the use of web page editors should be part of the curriculum for all preservice and inservice teachers. The web is becoming an important learning environment, and who better than teachers to create content that is pedagogically sound.

**Online Solutions**

Consistent with the trend to move more and more educational technology onto the web, web-based options exist for teachers and students wishing to create basic courseware. We looked at several of these in Chapter 8, in the context of e-Learning. With a low-cost, or even free, subscription, teachers can create basic hypermedia websites simply by using a browser. Some schools are moving toward a CMS (Content Management System) such as BlackBoard’s *CourseWeb*, that enables teachers to quickly and easily add content to a template provided for them by the IT services.

Additionally, many, if not most, of the multimedia productivity applications can Export or Save to .html, creating an "out of the box" web page or website. *Word*, *PowerPoint*, and *Inspiration* are especially adept at this task, which can be "buggy," but which is also an enormous timesaver, especially when teacher's can upload web pages to a school server quickly and easily. This is another instance when knowledge of HTML and website organization can be power.

Teachers wishing to explore one of the cutting edge, so called Web 2.0, solutions should investigate blogging or wikis. Originally designed as text-based online journals, blogs and wikis have now become multimedia in content. Free hosting services and applications such as Apple's *iWeb* or the wikis sponsored by wikispaces.com, make it possible for teachers to design entire units and courses around a blog or wiki, which can contain images and video, recorded narration or other audio, hyperlinks, and collaboration tools. Content, including voice recordings (called *podcasts*) and images captured on a multimedia cell phone, can be readily uploaded online—without programming as such—to a blog or wiki. This authorware solution is worth more than a passing glance. *Blogger.com*, *Blogdrive.com*, and *Moveabletype.org* are examples of free blog tools available to teachers and schools. Check out *wikispaces.com*, too.

An even newer tool is the WIKI, a web-based learning environment in which every teacher and student, every visitor, can be an author. Teacher's can now create classroom wiki's using free online tools such as *Wikispaces.com*²¹. As the wiki protocol and underlying programming environment improves, these powerful environments are supporting more of the multimedia objects we have highlighted in this text. As is also true for blogs, teachers generally have a choice of templates and, for advanced users, some ability to tweak the appearance and content of the website itself.

²¹ Some open source WIKI applications are also available, an even better solution for education, but one which requires the oversight of a good and experienced IT staff.
Elements of an Effective Educational Website

Visual web page editors and online templates offer the teacher a wide range of colors, patterns, clip art, fonts, animations and even sounds from which to choose. It is tempting, because it is fun, to "liven up" a classroom web page. It is generally true that students are drawn to "bells & whistles" and their use can capture a student audience. However, the wise teacher practices restraint so that content and navigation are not overshadowed.

There are some basic guidelines for educational web page design and content:

- **Use a "homepage" to organize your content clearly.** This page should contain a prominent title, clear navigation to sub-sections, your contact information, a link to your school's website, current important announcements (if any), and the date the page was last updated (your copyright). Some teachers include a "grabber," such as a word, fact or challenge of the day. If you don't want anyone to download or copy your content, this is the place to make that statement.

- **Organization is key.** Make a concept map or organizational diagram before you begin the website. There are many ways in which your content can be organized, but it should be navigable by "bullet words" such as Homework, Web Links, Announcements, Project A, Topic B, Class C, Trips, For Parents, Activities, etc. Fig. 10.2 illustrates a common website organization plan for an elementary teacher.

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22 Remember that Inspiration concept maps can be exported as HTML, creating the skeleton of a website!
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Fig. 10.2 Inspiration map of a teacher website

- **Provide the visitor with navigation links to and from every page.** Follow the rule of "3 Clicks and 30 seconds" - content should be accessible from any page with no more than three clicks of the mouse and in 30 seconds or less.

- **A web page should be up-to-date and useful.** If you are directing students or parents to websites, make sure the links work and the URLs are still active. Select the best; limit links to a "short list" of five or so and provide helpful annotations. Links to "outside" web pages should open in a "new window" if possible. This makes it easy for students to return to your home site.

- **Steer clear of clutter!** The eye is drawn first to images and will follow the direction in which they seem to "point" or "flow." Highlight key text with size and color contrast.

- **Break large content into several pages.** Student users do not want to scroll down, so focus your content on what will fit onto the monitor screen.

- **Clip art should be there for a reason and it should be consistent in style and size.** If it is used for navigation to subsections, be sure that text labels are included and that the same image is highlighted in the section to which it links.

- **Sound and animations should illustrate, not distract.**

- **Pictures should not be large files!** Use an image editor to resize them and compress them. If all else fails, put only one or two on a page and provide links to them. Many teachers post classroom pictures a free online picture gallery, such as Shutterfly, rather than putting them on a web page. Others use tools included with photo software such as iPhoto to create a quick, efficient web-based slideshow.

- **If you want users to download documents** (assignments, study guides, public domain text), make sure that they are available in a format that most, if not all, users can open. This would include .txt, .rtf and .pdf files (provide a link to the download site for Adobe Acrobat Reader). Compress large files if possible with WinZip or Stuffit.

- **If you include Quicktime or other movies on your site,** include instructions for viewing them and an indication of the file size.

- **Color schemes and fonts should be consistent throughout the site.** This helps your students to stay on track. Select and size your font so that it is readable by your student users and viewable on all computer platforms. Avoid dark backgrounds and background images (except perhaps on your homepage).

- **Copyright of images, text, audio and video must be respected.** Fair Use does not apply to publicly accessible web pages. Remember that you are modeling ethics for your children; when in doubt, either get (and note) permission or don't use the content! This

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23 San serif fonts, such as Verndana and Arial, are easier for students with disabilities to read. Similarly, text and background color should contrast. Black text on a cream-colored background is visually ideal.
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includes content, such as poetry and artwork, used to create student projects posted on your pages.

- **Do not include student names anywhere in the site.** Pictures of students should also be avoided unless your school has a legal parent/guardian "permission to use pictures" document on file. Keep this precaution in mind if you are sharing student-created projects or videos, which may contain names in authorship or "cast" lists.

- **Remember that student work is also copyrighted.** You must have the written permission of the student to post work on the Internet. Student work should also include a copyright statement. A recommended statement is: © 2004 XStud, student at My High School (First initial + four letters of last name).

- **Be sure to include an "About Me" page.** Introduce yourself to parents and visitors here, tell about your education, experience and philosophy and include information that validates you as a "professional expert" and interesting person. If you have a pet or favorite hobby or interest, you might want to highlight it here.

- **Double check your spelling and your facts!**

By all means use a website that you like as a model. It is also handy to use a web page evaluation rubric as a guide for designing your own page. Good rubrics, along with other useful resources for web page design, can be found at Kathy Schrock's Guide for Educators: [http://school.discovery.com/schrockguide/eval.html](http://school.discovery.com/schrockguide/eval.html).

**AUTHORWARE ESSENTIALS**

In Chapter 9 we looked at hardware and software tools for the creation and manipulation of multimedia and hypermedia. It is important for teachers to remember that good courseware is composed of many elements that work together to support and encourage learning; it is this rich environment that sets digital courseware apart from texts and reference books. The tools we have touched briefly upon in this chapter can stand alone, but they are greatly enhanced by the thoughtful use of other media authoring and editing tools.

Putting it all together, you should recognize by now the value of learning to use a few basic hardware and software tools with confidence: an image editor/paint program, a sound recording/editing application, one or more of the productivity tools highlighted in this chapter, a digital camera, and a scanner. You must also develop a basic skills set for multimedia authoring:

- Internet searching, URL bookmarking and capture, and file downloading,
- Use of the network and other options for file storage,
- Organization files and folders on your storage medium,
- Understanding of file naming and file extensions (digital file formats),
- Ability to use the menus and icon-based toolbars that most applications have in common,
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- Storyboarding or concept mapping (digitally or on paper),
- A willingness to try new things.

As is true of all teaching all of the time, content must focus upon the standards and goals, and upon the abilities of the students. It is possible for teachers to create masterful multimedia courseware that is entirely over the heads of the students; it is equally possible for teachers and students to create media rich courseware that is empty of educational content. Careful planning and a process of review and revision must, therefore, be part of all authorware use.

Even when all systems are GO, none but the most dedicated teachers can be expected to spend the time it takes to create quality courseware content unless school districts make it worth their while. The allocation of release time and money is an important pre-requisite to promoting this worthwhile work. An enterprising school district will gather together subject area and age group experienced teams of teachers to work, perhaps over the summer, to develop Web-based materials that can then be used by teachers not only throughout the district, but anywhere in the world where similar curriculum standards and content pertain.

LOOKING BACK

It is often difficult for gung-ho computerphiles to appreciate the technological timidity of some of their colleagues. The same problem arises when teachers find it difficult to appreciate the lack of academic motivation on the part of some students. Whatever the reason, it is a fact of life that must be accepted and dealt with through patience, understanding, unwavering support and encouragement. The variety of systems being introduced in schools today, exciting as they are to some, can be overwhelming to others. But, since the schools exist for the sake of the students, the teachers--whether computerphiles or computerphobes--must come to terms with the technology to some degree in order to provide an adequate educational opportunity for the students and, increasingly, adequate communication with the parents.

For many teachers, developing lessons around multimedia systems will not go beyond the simplest application of the technology unless and until comprehensive multimedia curriculum materials are available in an easily adaptable format to meet local approaches and the needs of local populations. Canned multimedia applications will generally not work for all but the minority of cases. For this reason, schools will in the long run need to tap the resources of their own technology-oriented teachers--the computerists--to train, and above all work, with those teachers who are naturally and understandably reticent about authoring multimedia systems on their own.

In the end, the students who have grown up around technology, and consequently are not afraid of it, will be the most avid users of the multimedia and other learning systems. Given the opportunity, these students will use the technology to access and assimilate the knowledge they need to achieve educational goals.

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24 The word "PowerPointless" has been coined by Jamie McKenzie to describe such projects.
25 A computerphile is a lover of computers. Its opposite is a computerphobe. Which are you?
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But children cannot do this without help. Teachers in the Information Age will need to be able to use technology in support of teaching, and, above all, they will need to know how to establish an environment in which students can safely and successfully control their own learning.

LOOKING FORWARD

Writing one's own software for computer-assisted instruction or multimedia learning is all well and good, and if you can do it, it will save money. But it will not buy the equipment, nor will it generate the funds to release you from teaching so that you can have the time to develop the software!

Money is by no means the only solution to the problem of restructuring schools to meet the needs of an Information Age, but there is precious little that can be done without it. Millions of dollars is available to fund technology projects in schools. The money is offered by foundations and other grant-giving institutions at the federal, state, and local levels. Some schools are making great efforts to win those grants. As a result, their students are benefiting from the best that educational technology has to offer.

It should be of great interest to teachers and administrators alike to learn how to effectively apply for grants. It will also be useful to discuss what steps should be taken to get the most out of a grant that has been won. Chapter 11 will therefore look at all aspects of writing grants.
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Chapter Eleven
Funding Technology Projects

Education pays, unless you are an educator.

_Evan Esar (1899-1995)_

Money enables a man to get along without education,
and education enables a man to get along without money.

_Marcelene Cox_

Resolve not to be poor: whatever you have, spend less. Poverty is a great enemy to human happiness; it certainly destroys liberty, and it makes some virtues impracticable, and others extremely difficult.

_Samuel Johnson (1709-1784)_

**LEARNING OUTCOMES**

Technology-rich and technology-ready (wired or wireless) classrooms are expensive to build and expensive to maintain. It should come as no surprise, then, that such classrooms still represent only a small proportion of the hundreds of thousands of classrooms in the United States, and the millions of classrooms worldwide.

In some countries, such as France, the education system is standardized at the national level. It always has been since the time of Napoleon. Thus, there is no disparity between one school district and another such as exists in the United States, for example. There is a national curriculum and students are ensured equal educational opportunity by virtue of the fact that the schools are all provided with the same facilities from a pool of taxation shared nationwide. By contrast, as long as school districts have to rely on their own, mostly local, resources, which is the case in the United States, there will be inequities resulting from the disparity of wealth from one school district to another.

In the United States, a few forward-looking, equity-conscious states such as Texas have implemented a so-called **Robin Hood** allocation of school taxes. Wealthier districts share the money raised for schools in such a way as to make sure that the poorer districts get enough to make it possible for them to fund equally competitive educational programs.

Unfortunately, equality of educational opportunity such as states like Texas are trying to ensure is not mandated nationwide. Indeed, in most states it is not even mandated **statewide**. Thus, the gap between the quality of schooling for the haves and the have-nots will continue to widen unless disadvantaged school districts fight for the allocations that will enable them to provide the same level of technological infrastructure enjoyed by the wealthier school districts.
To this end—no problems, only solutions!—numerous sources of funding can be tapped through the effective writing of grants.

But first, this chapter begins by briefly re-examining the goals of education in an information age. This will underscore the importance of finding the money to pay for the cost of ensuring that children have the opportunity to achieve those goals. The goals are looked at from the perspective of what the working world requires of schools in the way of a well-prepared, employable workforce.

The chapter goes on to list many sources of funding, outlines the key components of a strategy for successful grant applications, and discusses how to get the most out of external sources of funding once they have been won. Finally, the chapter discusses the important subject of evaluating grant-supported projects.

Here then are the topics that will be covered in this chapter:

- Introduction: Everything Points to an Increase in the Cost of Education
- The Goals of Education in an Information Age
  - The five competencies of effective workers
  - The foundation skills required of effective workers
- Sources of Funding and Support
- Preparing Grant Proposals
  - Steps in the preparation of a grant proposal
  - Strategies for successful applications
  - The qualities of a grantsperson
- Evaluating Your Technology Program
  - The purpose of evaluation
  - When should a program be evaluated?
  - The components of the evaluation process

INTRODUCTION: EVERYTHING POINTS TO AN INCREASE IN THE COST OF EDUCATION

Money is only part of the answer to the challenge of incorporating computers into the curriculum, but it is an important part. As Cheryl Williams put it in Branscum (1992): "Schools need funds and it's not a one-shot deal. ... you've got to buy the equipment, you've got to buy the software, you've got to buy the maintenance, you've got to buy the training, you've got to buy the updating, and you've got to phase it in."

Money is thus necessary to meet the needs of the people on the front lines in the struggle to update and restructure education. These are the teachers and administrators at the local level. This chapter discusses these sources of funding, and they are many. Aggressive school districts, many of them in underprivileged neighborhoods, are already dipping into this well of financial opportunity.

It should be remembered, however, that there is one small problem with grants. Once one has been won, the work has just begun. Applying for a grant implies a commitment to the
effort and innovation that the grant will fund. But as the old saying goes, "Fortune favors the brave."

Bork (1987), after presenting the case for technology-stimulated change in our education systems, estimated that an effort to coordinate full curriculum development on an international scale would cost about $10 billion over a period of six to eight years. Bork's estimate was made nearly 20 years ago; the estimated sum would be considerably larger now. This might appear to be a prohibitive expense. But, as Bork points out, it represented in 1987 just one-third of the cost of putting one person on the moon and "is about one or two days of the [pre-end of Cold War] military budget each year."

Following are some of the items that have to be factored into the costs of a free appropriate public education for the citizens of tomorrow's world.

• For a host of sound pedagogical reasons, including the effectiveness of technology integration for teaching and learning, the ratio of teachers to students needs to improve. Teacher-student ratios are indeed improving (from 1:27 in 1955 to 1:17.8 in 1995 to even slightly lower (16.4) by 2003). This means that schools need more, rather than fewer, teachers as time goes on, assuming a steady or increasing birthrate. Schools will also need more, rather than less, physical plant to house those extra classrooms.

• In the United States, the No Child Left Behind (NCLB) law means, in effect, that schools must redouble efforts to individualize instruction. Technology can help teachers customize the learning environment for each student, thus enabling individualized instruction in order to help assure that each individual child's learning needs are met. We can no longer pretend that there is some arbitrary, statistical bell curve that condemns an unacceptably high proportion of the population to educational nirvana. NCLB requires of good teachers every day that they ignite a spark of learning in children who formerly may have been given up on by others.

• The only relevant statistics in the schools of the future will be those that promote quality and a policy of continuous quality improvement in the way we serve each child's educational needs. The pursuit of quality in education carries a cost, but it is a cost that is recouped a hundredfold in terms of better prepared citizens and a society enriched by their participation in its economic and cultural affairs.

• As will be discussed more fully in the next section and in chapter 12, the changes in society in general, and in the workplace in particular, mean that, more than ever before, children must be given the opportunity for a lifelong education that will enable them to be fully contributing members of the information society.

• Everyone must get a fair slice of the education pie. The money needed for education must be shared equitably among all segments of the population, including children from all walks of life, of both sexes, and from all racial and ethnic backgrounds.

commitment to excellence and educational reform must be made at the expense of a strong commitment to the equitable treatment of our diverse population" (The National Commission on Excellence in Education, 1984).

• More money than ever will be needed to provide effective leadership in schools. Teachers especially must be given the time, ongoing training, and logistical and technical support necessary for them to get the job done. It would also help if teachers were adequately remunerated for their skills and dedication, as recommended in A Nation at Risk. After all, it is the children's lives and society’s well-being that are at stake.

• Educational technology is attended by a whole gamut of expenses ranging from the cost of the machinery itself, to the infrastructure necessary to support the machinery, and to the training and technical support of those who will use the teaching and learning systems.

Thus, winning grants is necessary to provide adequate funding to help the schools maintain a high standard of educational excellence relevant to modern times. This begs the question: “What is educational excellence and how is it to be measured?” This question has already been asked and answered. The obligation of schools to prepare students to function successfully in an information age is underlined in a report issued by the US Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS, 1991). So before we consider the nuts and bolts of grants, grant proposals, and grant implementation, let us take a look at this SCANS report in order to understand what are the competencies expected of workers in an information age.

THE GOALS OF EDUCATION IN AN INFORMATION AGE
A successful society is one that provides a high quality, lifelong education for all its citizens. This is a costly proposition, but the return on such an investment fully justifies the expense. The price that will be paid by a society that fails to commit to this goal will be devastating. This is the message that lies at the heart of A Nation at Risk (1984):

“We issue this call to all who care about America and its future: to parents and students; to teachers, administrators, and school board members; to colleges and industry; to union members and military leaders; to governors and State legislators; to the President; to members of Congress and other public officials; to members of learned and scientific societies; to the print and electronic media; to concerned citizens everywhere. America is at risk.”

Education is a key that opens many doors.

• Education prepares one to function successfully in a working world where manual skills are less and less in demand as compared to intellectual skills such as communication skills and problem-solving skills.
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- Education gives one the technical and intellectual skills to access and assimilate information.

- Education opens up a range of opportunities, allowing one to adjust and adapt to changing circumstances in the course of a career that will be subject to frequent change.

- Education enables one to make satisfying use of leisure time, bringing one to the point where one can educate oneself, broadening interests, acquiring new skills, and pursuing lifelong learning.

The Five Competencies of Effective Workers

The SCANS report (SCANS, 1991) identifies "five competencies which, in conjunction with a three-part foundation of skills and personal qualities, lie at the heart of job performance today." The competencies and foundation skills are seen as "essential preparation [for the working world] for all students." They are also essential preparation for further education and for life in general in the information age.

The five competencies required of effective workers are defined in the SCANS report as follows (emphasis has been added):

- Effective workers productively use Resources—they know how to allocate time, money, materials, space, and staff.

- Effective workers productively use Interpersonal skills—they know how to work on teams, teach others, serve customers, lead, negotiate, and work well with people from culturally diverse backgrounds.

- Effective workers productively use Information—they know how to acquire and evaluate data, organize and maintain files, interpret and communicate data, and use computers to process information.

- Effective workers productively use Systems—they understand social, organizational and technological systems, they know how to monitor and correct performance, and design or improve systems.

- Effective workers productively use Technology—they know how to select equipment and tools, apply technology to specific tasks, and maintain and troubleshoot technologies.

The Foundation Skills Required of Effective Workers

The foundation skills that are identified in the SCANS report as prerequisites to competence are:

- Competence requires Basic skills—including reading, writing, arithmetic and mathematics, speaking, and listening skills.
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- Competence requires *Thinking skills*—including the ability to think creatively, make decisions, solve problems, mentally visualize situations and solutions to problems, a knowledge of how to learn, and the ability to reason.

- Competence requires *Personal qualities*—including individual responsibility, self-esteem, sociability, self-management, and integrity.

The SCANS report (1991) reminds us of the primacy of education to American democracy:

“For over 200 years Americans have worked to make education part of their national vision, indispensable to democracy and to individual freedom. For at least the last 40 years, we have worked to join the power of education to the ideal of equity—for minority Americans, for the disabled, and for immigrants. With that work still incomplete, we are called to still another revolution—to create an entire people trained to think and equipped with the know-how to make their knowledge productive. (emphasis added)

“This new revolution is no less exciting or challenging than those we have already completed. Nor is its outcome more certain. All that is certain is that we must begin.”

Well, we *have* begun to overhaul the way we do education; change, after all, is inevitable. Fifty years from now, learning environments will look very different from what we see today. Computer-based learning is essentially constructive and interactive. It is less dependent on a specific location such as a classroom in a school. Children will still come together, but in smaller units, and in less rigidly regimented environments. There will be a great diversity of types of schools unified only by the requirement of preparing students to measure up to standards established by regional and/or national educational goals.

Teachers, too, will have different goals, different responsibilities. They will be more concerned with education and less concerned with classroom management because children will want to learn. With the technology in place and the teachers trained and committed to its use, we will be able to "pay attention to the needs of each student by individualizing the learning experience" (Bork, 1987).

No doubt, in due course, Herbert J. Klausmeier's dream of Individually Guided Education (Nussel, 1976) will become not the exception, but the rule.

**SOURCES OF FUNDING AND SUPPORT**

There are two types of sources for funds and equipment to support technology projects: steady sources and ad hoc sources. Steady sources of support are represented by institutions such as the US Department of Education, State Departments of Education, and corporations such as Apple, IBM, Microsoft, Dell, and so forth, which make a certain amount of grant money and/or equipment available every year. Ad hoc support is available
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on an irregular basis from foundations, local businesses and other local fund raising efforts.

Technology & Learning e-zine (http://www.techlearning.com/resources/grants.jhtml), an online resource for Education Technology Leaders, includes links to many websites with recommendations for funding for technology projects, including both steady and ad hoc sources. Here is a summary list of the kind of sources any K-12 teacher can consider when in need of funding for classroom technology resources. The list was compiled by Tom Wilson in an early edition of the T&L magazine (Wilson, 1992).

**District general funds** Money raised from local taxation, especially real estate taxes. A slice of this pie goes to local schools. More and more school districts set aside money from this pot to be allocated specifically for educational technology.

**Funds for special educational categories** Budgets for Chapter 1, learning disabled, and other special needs students often allow for support of technology-related projects.

**State-run educational improvement programs** Most states today make some provision for budgetary support of technology-based programs for schools. In Pennsylvania, for example, the Information Technology Education for the Commonwealth (ITEC) Act, passed in 1984 and described in Dunlop (1986), was intended "to (1) provide teacher training in computer information technology, (2) help design computer-oriented elementary and secondary curricula, (3) assist teachers and school administrators in the evaluation of educational computer software, (4) administer and fund individual schools' proposals to acquire and upgrade computer equipment and implement computer-oriented instruction, (5) assist in the coordination of the purchase of microcomputer hardware and software for Pennsylvania schools and (6) loan equipment and computer software to non-public schools." The ITEC program operated in Pennsylvania for ten years, till 1995, when it was superseded by a new series of state-funded programs called Link-to-Learn in support of K-12 technology integration.

**Parent-Teacher Organizations** All over the world, schools rely on such organizations/associations for fund-raising. Computing technology is an ideal focus for PTA/PTO efforts since it has such a direct impact in the classroom.

**Grants** There are innumerable sources for grants of all kinds, whether from local, state, or federal government, or from private institutions such as foundations or corporations. The granting agencies send out Requests for Proposals (RFPs) asking interested parties to submit detailed requests for targeted funding. This process is discussed in detail later in the chapter.

Federal Computer Week e-zine noted (January, 2004) that “federal grants for state and local education continue to rise, reaching almost $35 billion in fiscal 2004 including more than $700 million specifically for technology programs, according to officials from the market research firm Input.” The article goes on to point that “much of the increase comes through the No Child Left Behind Act of 2001, which established several grants programs to improve education through technology and access to technology.”
General obligation bonds Some school districts win electoral support for school bond initiatives to support improvement of capital facilities, including technology-related equipment. School districts have, for example, persuaded the electorate to agree to a one mil increase in local taxation to fund the infusion into the schools of the latest multimedia technology (Foreman, 1991).

Lottery money States that conduct lotteries can be lobbied to allocate some proportion of the supplemental revenue to educational technology.

Partnerships with colleges or local adult-education programs This idea was successfully implemented at the Minute Man Technical High School in Lexington, Massachusetts. The program offered courses for parents and local citizens with revenues allocated to improve technology-based education at the school. Many state and federal technology grants are predicated on collaboration between universities and local school districts.

Vendor contributions Stanton (1992) provides details of generous programs sponsored by Apple Computer, Inc., IBM Corporation, Microsoft Corporation, NEC Corporation, Tandem Computers, Tandy Corporation, and Toshiba America Information Systems, Inc. The combined dollar value of the grants and product donations made by these companies alone came to well over $200 million a year.

Foundation grants The Michigan State University Libraries maintain a useful web resource at http://www.lib.msu.edu/harris23/grants/2comptec.htm listing grants in the area of funding opportunities for computer technology for non-profits such as K-12 schools.

Parent workshops and after-school student instruction This source of funding is similar to the partnerships with colleges and local adult-education programs already mentioned. Basically, the school sets itself up in the business of education, offering workshops for a fee to parents, students, and local citizens. The teachers are paid for their services as instructors, so it is an opportunity for them to augment their income. Like any business, the program has to be well-organized and efficiently run. The potential for net profits can be substantial.

Lease/purchase agreements Where the technology is leased from a vendor, rather than purchased outright. This arrangement has the advantage of reduced initial financial outlay, thus spreading out the financial burden involved in the purchase of the hardware, software, and support for technology-based programs.

Local business donations As far as computer-based technology is concerned, the major contribution of local business is expertise and training. Many schools are now looking to develop close liaisons with local businesses for purposes of educational support. Financial donations are also available. Outdated computer hardware and software, which a business may be replacing with state of the art systems, can often be put to good use in a school, especially when there is a teacher or staff member who has the motivation and the knowledge to incorporate it into the curriculum. However, such outdated equipment
can as often be more trouble than it is worth, and may be best utilized as part exchange for more up-to-date systems.

PREPARING GRANT PROPOSALS

Steps in the Preparation of a Grant Proposal

A useful paradigm for developing a grant proposal is the classic problem-solving model advocated by Polya (1945) which we already applied, in chapter 4, to the problem of designing computing environments. A grant proposal is designed to help solve the problem of coming up with financial support for projects. Once a request for proposal (RFP) has been received from a funding source, Polya's four steps in the problem-solving process can be applied as follows to the development of grant proposals:

**Step One: Understand the problem** This is equivalent to researching the educational environment for which the grant is proposed. Starting with the current state of affairs, identify the way learning currently takes place: methodologies, equipment used, student profiles, and so forth. This will unearth opportunities for improvement that can benefit from technology. These improvements would be stated as objectives. The process of understanding the problem will also identify constraints: unavoidable limitations on the scope of the project (budget, physical plant, learning abilities, etc.). Very important at this early stage: involve the teachers and students who will benefit from the grant. Continue to involve them throughout the process, thus helping them to commit to the project if and when it is funded.

**Step Two: Devise a plan** At this stage, you have a reasonably good understanding of the problem the grant proposal is designed to address. Devising a plan involves drawing up in detail the series of steps that will lead to the achievement of the objectives spelled out in Step One, as well as a specification of all necessary equipment and support. It is important at this planning stage to draw up more than one plan. There is never only one solution to any problem. Eventually, of course, you will need to select the one best strategy for presentation in the grant application proposal.

**Step Three: Carry out the plan** Prepare the proposal. This should be relatively straightforward if you have conscientiously completed the first two steps. In fact, you will already have written much of the proposal.

**Step Four: Look back (Evaluate the plan)** Review the proposal carefully before signing off on it and sending it out. Especially important is to have others review it, including people who had nothing to do with the preparation of the proposal. The more objective the appraisal the better. Be open to other people's ideas and perspectives. Only a fool thinks he or she has all the answers.

Following these steps will greatly improve your chances of success. The next section outlines some other strategies that are important in winning grants.
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Strategies for Successful Applications

**Get to know your grant officer** Grant officers are individuals at funding institutions who act as liaisons between those seeking funds and those who determine the distribution of those funds. The grant officer is a key resource for information about the focus of a grant application, about what funded objectives should be emphasized in the proposal, and so forth. It is important to establish a close relationship with a grant officer, and maintain that relationship over the life of a grant, which can span many years.

**Each school district and each school should appoint a grantsperson for grant coordination** An individual staff or faculty member at the school should be responsible for coordinating grant applications. This individual should be allocated time to do the job. This is the single most important recommendation for success in raising grant money. If something is worth doing, make someone responsible for getting it done. In general, it is a waste of time making announcements and putting up signs encouraging people to do this or that, like write grants and so forth. Everyone knows that there is a lot of hard work involved with winning grants, so it is essential to appoint a staff or faculty member to be responsible for coordinating grant applications. Included in that responsibility will be making other teachers aware of the grants that are available, to encourage them to get involved, and to work with them to develop proposals. This individual “grantsperson” might also be responsible for working with teachers in the implementation and evaluation phases.

Teachers should always know that they will have active support if they apply for grants. The more teachers are involved, the better. Schools that rely on one or two heroes to make things happen are not usually as effective as schools where the administration is able to create a spirit of teamwork among the faculty and staff. Schools should consider the cost involved in freeing up a teacher or staff member to coordinate grant acquisition as *seed money* for the many profitable projects that will result from the investment.

**Allow for the hidden costs of grants**

- *Grants take expensive time and effort*; to prepare the grant proposal, to implement the grant once won, and to evaluate the impact of the grant.

- *Grants often require a direct or indirect matching investment*. Some grants are offered on the condition of matching funds. This is because matching funds imply a commitment on the part of the institution that receives the grant, thus giving the grantor some assurance that the money, equipment, or services will not be wasted. An indirect matching investment might be the lifetime cost of support personnel, power supplies, peripheral (support) equipment, office supplies, and so forth.

- *Grants carry the cost of resistance to change*. Introducing even one computer into a classroom demands change, unless, of course, the computer is not used. That there are so many unused computers in classrooms confirms the fact that change is always difficult. Schools that acquire and implement grants must factor in the effort...
involved dealing with this very human resistance to change. This is why it is important to involve in the grant proposal process those who will be affected if the grant is won.

Whenever possible, use the computer to write the grant proposal. The computer comes in handy even when a special form must be used. The form itself can sometimes be reproduced on the computer. These days, however, forms for grant proposals more often than not are available for download from the grantor’s website. Most grant proposals have sections that involve freeform text, which means that they can be quickly filled out by cutting and pasting from pre-used electronic forms.

The school’s grants coordinator should keep a database of grant applications and proposals and make them available for reference to those involved in writing grants. This kind of support can take much of the drudgery out of the task of applying for grants. Usually, grant proposals must be accompanied by the curriculum vitae of those responsible for implementing the grant. These should be kept on a computer, too, so that they can be easily updated whenever necessary.

It is surprising how many people fail to apply for grants because of the paperwork involved. The computer can help take a lot of the tedium out of this tough, but important, task.

If at first you don’t succeed, try, try again. Do not be disappointed if you fail to win every grant you apply for. Bear in mind that there may be hundreds of others who are applying for the same grants. You are selling yourself and your ideas to the grant awards committees. Unless you are applying for grants that are of interest to a very limited number of people, you should expect to win no more than, perhaps, one in five of those you apply for.

The excellence of a proposal is, therefore, no guarantee of success. This factor alone discourages many from applying for grants. This is why grant applications should be coordinated. The more people a school or school district can involve in preparing grant proposals, the easier it will be to generate a critical mass of applications, thus upping the likelihood of success.

The coordinator should not simply encourage people to apply for grants. He or she should actively assist in the development of proposals. Most teachers will not apply for grants on their own. Many teachers will get involved if they feel they are part of a team.

A grants coordinator should try to identify whatever is the current "hot" area for grant/foundation funding. The grantor’s Request For Proposal (RFP) will usually indicate a general target, such as "N number of dollars for educational technology." The RFP form will ask you to provide responses to a set of questions that will allow you to map out in detail what use you propose to make of the money or equipment. One year, a grant’s focus may be multimedia, another year it may be networks. This "hot" area will differ from grant to grant, as well as from year to year.

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1 William E. Hickson, Try, Try Again.
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What this means in practical terms is that experience will help you cut down on the hit and miss nature of grant applications. The more grants you apply for, the more you are likely to win; assuming, of course, that you learn from each experience. Hence the next recommendation.

**If your grant proposal is turned down, find out why** Often an institution funding grants will tell you why your proposal was turned down, even if you do not ask. This is free advice from experts in the business, so you should welcome it as such. Sometimes, indeed, an institution will send a copy of the winning proposal as a model for future applications. When this is not the case, you should write for a formal statement so that you can learn from the experience.

**The Qualities of a Grantsperson**

**A grantsperson must have excellent organizational skills** He or she not only needs to be able to coordinate the grant application process, but also must be good at delegating work. This is not simply in order to increase the number of proposals submitted, but also to encourage other teachers to get involved with applying for grants. If teachers are committed to a project, they will be more likely to be enthusiastic when it is implemented in their school.

**A grantsperson must be reliable when it comes to meeting deadlines** A sure way to lose a grant is to submit the proposal even one hour, let alone one day, late. The first process carried out by people reviewing grant applications is the development of a short list of candidates. Only those proposals on the short list receive close scrutiny. Proposals that arrive late are the first to be eliminated; they are not even looked at.

**A grantsperson must be a good writer** Much of a grant proposal's success depends on the quality of the presentation. The proposal is designed to sell the project. A grantor will be more likely to look favorably on a proposal that is couched in credible terms. Not only must the writing be mechanically sound, but it must also get to the point, capture the reader's attention, and convey the strong impression that the funded organization will maximize the potential afforded by the grant should it be forthcoming. If your proposal is poorly presented, no matter what its other merits, it will probably be eliminated from the short list.

**A grantsperson must be good at working with people** So much work is involved in preparing proposals that it makes sense to get others involved early in the process of developing the grant application. This is especially true of those who are likely to benefit most from the resulting grant. People who are good at working with others generally have strong communication skills, lots of patience, and a genuinely friendly personality. These are invariably the qualities of a good grant writer, too.

It may seem that it would be difficult to find someone with this set of qualities. As it happens, because these same qualities are required of good teachers, there should be plenty of potential resident grantsperson candidates in every school!
EVALUATING YOUR TECHNOLOGY PROGRAM

The Purpose of Evaluation

Frequent evaluation is the key to any system's on-going success. Sometimes we hear programs being praised purely because they happen to exist. How many times have we heard something like this:

"Last year, a sum in the amount of $500,000 was spent on the purchase and installation of additional student computing facilities. We feel that this allows us to offer our children an educational experience that will prepare them for the technological age."

(Round of applause… Hear, hear! Jolly good show!)

Sound impressive? Well, yes, but what does it mean?

There is no mention of computing facilities for the teachers. There is no mention of any allocation of time for teachers so that they can learn how to use the new technology. In fact, there is no mention of how "additional student computing facilities" will make any difference at all!

This is what some school districts pass off as demonstrating their commitment to providing the best possible educational experience for their students. As Branscum (1992) observed, "for far too many, computers are ... used in tragically misguided ways."

Of course, making money available is important. Computer-based education is a lot more expensive than "chalk and talk." But, if the money invested is to yield an acceptable return, there must be accountability in terms of results clearly demonstrating improvements along criteria laid down by the managers at all levels of the educational process.

Accountability is possible only if there exists a clear set of criteria based on a school district's educational goals. Routine evaluation is the process that puts accountability under the magnifying glass by examining a system's success against established expectations.

Think of evaluation of a learning system, whether designed around computer technology or not, in the same way as you would think of service on your car or check ups on your health. The idea is to improve the performance, and ultimately extend the life, of the system under examination.

When Should a Program be Evaluated?

Evaluation that is done with care and sensitivity and that is approached from a positive perspective helps maintain the healthiest possible status for a system. Therefore, the best time to evaluate a program is when it appears to be working perfectly. In the same way, the best time to service a car is when it is running well, and the best time to check out the human body is when it is in a robust, healthy state. Evaluation of a learning system should also be routine, with the objective of checking to ensure that initially stated goals continue to be met.
Chapter 11: Funding Technology Projects

Evaluation also has the purpose of identifying opportunities which will lead to continuously improving upon the state of a system.

It is usually the case that new and often unexpected positive or negative aspects of a system are identified during the process of evaluation. Negative outcomes that are identified early can be circumvented and avoided for the future. Positive outcomes can be seized as opportunities for extending the potential of the system.

For example, a *Teaching and Learning With Technology* project described in Klenow, 1991 had several unexpected outcomes, among which were the following:

- Teachers discovered that "they no longer want to teach without technology," and that "they can be omnipresent without being controlling."
- Teachers and students discovered that "they have a greater tolerance for ambiguity and that both parties have ownership in the teaching/learning process."
- "The project forced [the teachers to engage in] conscious discussion of their roles as teachers causing them to take stock of themselves and their work."

Many other *Teaching and Learning with Technology* projects are described on the Web at [http://www.tlt.ab.ca/projects/projects.html](http://www.tlt.ab.ca/projects/projects.html).

There is so much richness in experience, with the result that surprises like this are the norm, rather than the exception. The beauty of discovering unexpected outcomes is that, once discovered, they can be handled—enhanced if the outcomes are positive, corrected if they are negative.

This is why evaluation should be conducted when the system is in a healthy state, not when it is already on its last legs.

**The Components of the Evaluation Process**

**Draw up evaluation instruments based on the objectives for the project stated in the proposal** The first step in evaluating a technology program is to identify and spell out the objectives of the program. These objectives should be sufficiently specific as to be measurable. In the case of a technology program funded by a grant they will already have been spelled out, for the most part, in the grant proposal. These measurable objectives would then become part of the evaluation instruments, which are comprised of a series of check points and questions regarding predetermined aspects of the project. Questionnaires, pre and post tests, and portfolios of student work are examples of useful evaluation instruments. These evaluation instruments would be used during the regularly scheduled process of data collection about the project.

Reviewing the objectives spelled out in the proposal has the following benefits:

- The objectives will assume new importance prior to implementation of the grant. Implementers will approach the process of implementation more focused on the outcomes from their efforts. If you know where you are going, you are much more likely to arrive at the correct destination.
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- With the passage of time, it may well be that stated objectives need to be adjusted or augmented to reflect change in circumstances that have occurred since the grant proposal was originally drafted. New objectives may have become apparent. To the extent that they do not compromise the essential purpose of the grant, these additional objectives should be considered for inclusion alongside the original objectives to help guide implementation and evaluation.

- Some objectives will not be as important as others. Reviewing objectives will enable the implementing team to prioritize them, thus reducing the danger that important goals might become sidetracked by an unwarranted preoccupation with ones of lesser importance. For example, one objective of introducing new computer-based technology might be to foster computer literacy (familiarity with, and appreciation of the value of, computer technology) among the students involved in its use. Another objective might be to improve students' writing skills as measured against norms established by some specific, standardized assessment instrument.

These are both laudable objectives; the first, however, should not take priority over the second—and should not be touted as a significant outcome from the project—because, to a large extent, computer literacy will take care of itself in the world of today's child, where computers are, for the most part, taken for granted anyway. On the other hand, the second objective, improving students' writing skills, will always represent a crying need in schools.

Computer-based systems for developing writing skills have been shown to augment other methodologies in pursuit of this objective, and, therefore, fostering improved writing skills using computer-based systems is a goal worthy of diligent application. As Pillar (1992) observed, emphasis on computer literacy can too easily become a cop out when justifying computer use in schools. It covers up an all too common reality: money spent on computer technology has been wasted on poorly focused, poorly supported, poorly implemented systems.

Use the evaluation instruments to conduct the evaluation Each time data are collected, they should give a snapshot of the state of the environment. As Kinnaman (1992) explains, when it comes down to it, evaluation involves "stopping at both predetermined and random points on your journey to look around and answer the questions: "Do the surroundings look the way we expected them to look at this point? and How happy are we with our progress?"

Kinnaman (1992) recommends that we look at more than student achievement on tests when conducting an evaluation. Pre and post tests, for example, are a useful barometer, but not a completely reliable one. Tests can be unconsciously biased or inappropriate. Other useful, though more time-consuming, measures involve:

- "performance assessment [which] focuses on what the student can do" (projects, portfolios of work accomplished);
- questionnaires and interviews to sound out "student attitudes ... motivation, effort, or enthusiasm";
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• and similar instruments to sound out "teacher attitudes and behaviors ... teacher motivation ... ways in which teachers interact with each other [or] with students."

Evaluation is an opportunity for improving the quality of a funded project. It should begin the moment the decision is made to prepare the grant proposal and should continue at regular intervals throughout the life of the project. The goal is the pursuit of excellence, which can be sustained only if we accept that it is by no means guaranteed. Educational technology-based projects that are evaluated in this way are far more likely to succeed. They are also more likely to provide a wealth of experience that will lead on to improvements in other areas of educational endeavor. As the English philosopher Aldous Huxley remarked: "Experience is not what happens to a man. It is what a man does with what happens to him."

LOOKING BACK

In recent years, education systems all over the world have come under scrutiny and been found wanting. In some countries, the systems are criticized as being too elitist, excluding too many of their youth from access to higher levels of education. In other countries, the systems are criticized for the declining quality of the graduates, at least as compared with 20 or 30 years ago. The United States, "a nation at risk," has also been found wanting. Education is at a crossroads. There is a sense that major change must occur if our schools are to meet the needs of future generations of children. But that change is expensive. In better economic times, schools can expect an adequate level of federal, state and local support. But, by all accounts, national and global economic constraints are going to hamper educational progress through the remainder of this century, unless we take matters into our own hands.

The Computer Learning Foundation is a nonprofit educational foundation serving the United States and Canada. Its primary focus is on developing computer competence among youth. It is officially endorsed by 54 U.S. and Canadian departments of education and 25 national nonprofit organizations. Funding for the foundation comes from U.S. and Canadian corporations, local businesses, and individuals. It is representative of many governmental and private philanthropic organizations in that it is dedicated to helping the deserving needy pull themselves up by their own bootstraps.

That is what grants and donations are designed to do. Ideally they are not given away arbitrarily. It is as if the sponsors are saying: "We have substantial amounts of money and equipment to help you. Show us that you understand the educational needs of children in a modern society, show us that you are likely to make the most of any help we give you, and we will provide you with the wherewithal to pursue excellence."

Sometimes we must grasp opportunities for change and make things happen.
LOOKING FORWARD

It is now time to turn our attention to the impact the computer has had, is having, and will have on society in general, and on education in particular. To do this we will shift our focus from the computer as an entity in itself to the computer as a factor in social change.

Chapter 12 will examine a selection of the social impacts of advances in computing science. How has the computer extended human capabilities both as individuals and as social groups? How has the computer enabled us to effect significant change in our social institutions, including education? The accelerated pace of this change (Toffler, 1971) means that we cannot afford to wait on the sidelines. Non-participation will do a disservice not only to ourselves, but more importantly to the children with whose future we are entrusted.

Chapters 12 will go on to examine various ethical and legal issues that have arisen with the proliferation of computer-based technology. Privacy has become a luxury, while inequitable access to the benefits technology brings are creating a widening gap between the haves and have-nots. Computing technology is also spawning a new kind of criminal with the technical skills to carry out computer-assisted crime. Our students need to be aware of these problems.

As the saying goes, Knowledge is power. But here’s another saying that is equally relevant: Forewarned is forearmed!
Chapter Twelve
Computers, Education, and Society

It is useless to bemoan the departure of the good old days of children's modesty, reverence, and implicit obedience, if we expect merely by bemoaning and by exhortation to bring them back. It is radical conditions which have changed, and only an equally radical change in education suffices.

*John Dewey (1859-1952)*

Science cannot stop while ethics catches up.

*Elvin Stackman*

Some are born good, some make good, some are caught with the goods.

*Thomas Jefferson (1743-1826)*

For every man there exists a bait which he cannot resist swallowing.

*Friedrich Wilhelm Nietzsche (1844-1900)*

A teacher who can arouse a feeling for one single good action ... accomplishes more than he who fills our memory with row on row of natural objects, classified with name and form.

*Johann Wolfgang von Goethe (1749-1832)*

**LEARNING OUTCOMES**

The children in our classrooms have been raised in a world where computers and computer-based technologies have changed the landscape of their daily lives. We even have a special name for these young people who've grown up since, say, the late 1980s; we call them "digital natives." The rest of us, who've had to get used to this new digital world later in life, are called "digital immigrants!"

What does this digital reality mean for our students? What is their mindset? How does it affect their day-to-day lives? That is what this chapter is all about.

Our examination of the sociological impact of computers begins with a broad sweep across the canvas of our world. We will consider the computer as a tool that supports research, enables discovery, stimulates invention, fosters environmental and organizational control, and facilitates communication between individuals and groups, which in turn fosters understanding, cooperation, and accord. We will then concentrate on the increasingly central importance of education as the key to the survival of the individual in a modern, computer-enabled, information-based society when what you know (and what knowledge you know how to easily access) is at least as important as what you can do.
Chapter 12: Computers, Education, and Society

Lest we have too rosy-eyed a view of the computer's impact on our world, we also will examine the dark side of the rapid proliferation of computer-based technologies. Privacy is threatened—some would say it is dead and gone. Inequities—the so-called Digital Divide—are becoming more, rather than less, pronounced. New kinds of crime have emerged, along with new risks to children—some of which we already discussed in chapter 8.

Teachers and students need to be aware of these negative aspects of computerization so that they will be less likely to become victims of the negative outcomes of a computerized society. The knowledge that comes with this awareness empowers the individual, and that is what learning is all about.

Here then are the topics that will be discussed in chapter 12.

- Computers, for good or ill, are transforming our world
  - Extending the Capabilities of the Mind
  - Extending the Capabilities of the Body
  - Robotics
  - Help for the Disabled
  - Population Explosion
  - Species Extinctions and Climate Change
- Education and the Information Society
  - Information Overload
  - Information and Wealth
- The Place of Computer-based Learning in Schools
- Ethical and Legal Issues and Computers
  - Privacy Invasion
  - Computing Inequities: The Digital Divide
- Security: Hacking and Cracking
  - Computer Viruses
  - Worms and Trojan Horses
  - Spyware and Spam
  - Trespass of Computer Systems
  - Money Theft (Embezzlement)
- Steps Schools Should Take to Secure Computer Networks

COMPUTERS, FOR GOOD OR ILL, ARE TRANSFORMING OUR WORLD

Not all computerization is for the better. Weizenbaum (1976) reminds us of the words of John Dewey, who wrote: "Every thinker puts some portion of an apparently stable world in peril and no one can predict what will emerge in its place." The invention of the computer has indeed changed the world and even, directly or indirectly, put the world in peril.

According to Joseph Weizenbaum, the very existence of the computer makes it possible to manage more data than ever before. This has resulted in our collecting more data than ever before. While this is a boon to researchers, it also affects the way we solve problems. As Weizenbaum points out, "the computer did arrive 'just in time.' But in time for what? In time to
save—and save very nearly intact, indeed to entrench and stabilize—social and political structures that otherwise might have been radically renovated or allowed to totter under the demands that were sure to be made on them." The computer has "buttressed" and "immunized" social and political structures "against enormous pressures for change." Weizenbaum goes on to question the use of the term Computer Revolution, arguing that computers have done more to prevent change than bring it about.

On the other hand, Beniger (1986) makes it clear that increased levels of control promote progress in any field of endeavor. The computer, by giving us greater control over systems such as transportation, communications, banking, science, health, and industry, directly affects the rate of discovery, invention, and progress. Artists and artisans from all walks of life—including teaching—recognize the potential of the computer to extend human capabilities in the realms of creativity and problem-solving. The computer thus seems likely to have a beneficial impact on our world. Let us begin then by briefly examining some of these beneficial social impacts.

Extending the Capabilities of the Mind

Alan Turing, an English philosopher and mathematician whom we talked about earlier in this book, published a paper in 1937 which anticipated the invention of the modern electronic digital computing machine. Turing described a theoretical, logical machine (Turing, 1937), now known as the Turing machine, which would be capable of processing any computable function.

Fig. 12.1 Alan Turing, Mathematician and Cryptographer, 1912-1954

Kurt Gödel (1931) had already shown that there was a class of problems in mathematics that were simply unprovable. But what Turing established for the record was that, given time, we could build a machine that could come up with the solution to any computable problem we set our minds to! So he called his theoretical machine "The Universal Machine."

Fig. 12.2 Kurt Gödel, Mathematician and Logician, 1906-1978

Turing might be called the Father of Artificial Intelligence (AI) because of his early recognition of the electronic computer's extraordinary potential as a 'thinking machine.' He liked to compare the computer to the human brain. As Hodges (1982) notes, Turing had always been interested in physiology. Certainly, he showed a thoroughly modern understanding of neurophysiology when, in 1930, he observed: "We have a will which is able to determine the actions of the atoms probably in a small portion of the brain... The rest of the body acts so as to amplify this."
Chapter 12: Computers, Education, and Society

The brain proposes, the body disposes. By analogy the computer, like the brain, can be programmed to control an endless series of machines and environments which would otherwise need the presence of a thinking human being. These would include social or community environments such as transportation, all areas of science (including health and welfare), communications (including entertainment), agriculture, accounting and other processes in business and industry, and so forth.

More and more tasks previously carried out by intelligent human beings are now being given over to suitably programmed computers. The computer is just a dumb machine which, once programmed, is able to work tirelessly, processing data of all kinds at high speed and at little cost. It is also much less error-prone than humans. This is why folks such as Gottfried Wilhelm von Leibnitz and Charles Babbage racked their brains to devise automatic calculators: human computers just make too many mistakes.¹

Ironically, the electronic digital computer performs mindlessly operations that enhance our ability to think. Human thought is predicated on knowledge, which is the fruit of experience leading to acquired and assimilated information. The representation of this accumulated knowledge is made possible by symbol systems (data—both audio-visual and verbal—expressed in the lexicon of a medium such as language, music, or art). We think using the tools of the language(s) we have learned. Computers come in handy by allowing us fast, easy access to the information that we need to think about anything at all.

Teachers everywhere have a golden opportunity today to improve the educational experience for their students by creating an environment in which children can take advantage of computer-based technologies to extend their ability to think and learn. This is true even in developing countries where access to computers is poised on the edge of becoming ubiquitous.

This is because access to the internet is becoming globally ubiquitous, thanks to wireless communications technologies such as WiMax. WiMax does away with physical wires or cables altogether, allowing users with mobile (cell) phones, or with wireless cards in their computers, to pick up the internet and all that the internet involves (World Wide Web, Instant Messaging, Texting, Internet phone, etc., etc.) anytime, anywhere. WiMax, not yet available everywhere in

¹For more on the History of Computers, see my PowerPoint http://www.pitt.edu/~poole/historyofcomputers.ppt
the United States, will be available throughout the subcontinent of India, for example, by 2010. By 2020 it is likely that anyone anywhere—rich or poor or anything in between—will have access. This will change everything. Let’s start with writing.

Research has shown that writing is a pre-eminent learning tool. The very act of writing—of organizing thoughts into a coherent form—is an important step towards understanding, which is itself a fundamental building block of learning.

Research also has shown that children's writing skills are considerably enhanced when they use the computer as a writing tool. This is partly because they are liberated from the constraint of having to form letters by hand. But it is also because they are able to capture their thoughts and, above all, revise their thoughts much more easily using a word processor than with pen and paper.

The computer thus promotes learning by promoting writing as well as verbal communication. It also promotes learning by taking much of the drudgery out of processing data.

Put the computer in the hands of trained (educated) individuals and those individuals can “think” with their fingertips, processing and analyzing huge databases of information on the way to drawing conclusions about our world—in science, technology, business, government, philosophy, the arts—which advance our understanding and increase our ability to control our environment.

As we shall see later in this chapter, this increasing level of control is not necessarily a good thing. The computer helps us think; unfortunately, it can’t help us act morally or ethically. That is something we still have to do on our own.

**Extending the Capabilities of the Body**

In general, you can say that Artificial Intelligence (AI) is anything we haven’t figured out how to do yet using programmed computers. Hardly a day goes by where we don’t hear about some pretty amazing thing someone has programmed the computer to do. All it takes is an idea—such as Dan Bricklin’s first electronic spreadsheet (VisiCalc) in 1978, or Tim Berners-Lee’s World Wide Web in 1992—along with the technical ability to implement that idea in computer program code.

This implementation is not easy to do. Lots of people come up with ideas that remain in the realm of fantasy. But folks such as Dan Bricklin, Tim Berners-Lee, and Bill Gates (to name but a few of those talented people who not only understand what the computer is capable of, but who also have the ability to make things happen) are quietly or not so quietly, one keystroke at a time, developing things for the computer to do for us that are beyond our wildest dreams.

Most, if not all, animals use tools to help them accomplish physical tasks. Think of monkeys using sticks to lure ants out of their nest, or beavers building dams to make it easier for them to get food. Human animals have come up with lots of tools, too, to help them do things. Indeed, when it comes down to it, technology may be defined as “tools that help us do things.”

Computers are no different from other tools in this respect, except that, being *Universal Machines*, they have a lot more flexibility and versatility than most other tools. More importantly, computers can be programmed to operate autonomously, without human intervention.

Welcome to robotics.
Robotics

Scientists routinely are able to pick up and examine rocks on the surface of distant planets. Back on earth they slip their hands into “gloves” that are connected by radio signals to the "hands" or, more accurately, claws of robots that have been sent to those planets to do the scientists’ exploring for them. Robots such as the lunar rover (Fig. 12.5) have cameras fore and aft to transmit pictures of the objects they sample.

![The Lunar Rover](image)

**Fig. 12.5 The Lunar Rover**

They also have sensors which can pick up particulates in the air or analyze minerals on the ground. Robots give the scientists the opportunity to virtually visit the planets in our solar system. They manipulate the robots remotely as if they were there on the planets themselves. The robots respond precisely and delicately, controlled by scientists from hundreds of thousands, maybe even millions, of miles away.

Neither man, woman, nor robot could get to other planets (or moons) without computers that have been programmed to control the whole process of space exploration from conception to realization. Remotely operated vehicles (ROVs) are used to study the ocean depths (Fig. 12.6), explore volcanoes, investigate unexploded bombs, or to check out locations that may have been contaminated as a result of toxic emissions.

![Submersible ROV](image)

**Fig. 12.6 Submersible ROV**

In general, ROVs allow us to go where it would be either very difficult or very dangerous for us to go in person.

Robots, in the form of robotized cameras, also can manage and control places where we live. In the United Kingdom, for example, robotized cameras rule the road. If you go to the UK for a
Chapter 12: Computers, Education, and Society

visit, beware if you rent a car. Wherever you drive, cameras will be watching you! This is very convenient for the UK government, since the cameras are controlled by computers that automatically take pictures of the license plates of speeding drivers. They search and find the license plate number in the database of licensed drivers (or vehicles owned by rental car companies), and automatically send you (or your rental car company) a speeding fine notification through the mail—without a single policeman in the loop!!

Cameras rule! George Orwell, of Big Brother fame, would not be surprised in the least to see what is happening in so-called free societies such as the UK. But then, maybe we have to give up freedoms in order to guarantee Freedom.

Now there's a conundrum!

Help for the disabled

Today we can say that if a person can control the movement of any part of his or her body—the raising of an eyebrow, the blink of an eye, the flick of a finger, the twitch of a toe—a computerized device can be designed to use that movement to allow a person with a disability to function independently in the mainstream of society.

In the United States there are over 50 million people with some kind of physical disability—that’s 1 in 6 of the population. The growing industry for computerized devices to assist this segment of the population has already produced inventions that give one reason to hope that the term handicapped will eventually all but disappear from our vocabulary.

Consider what has already been achieved.

Consider a quadriplegic, paralyzed from the neck down, who has a voice-controlled robot programmed to be his companion, preparing his meals, feeding him, fetching and carrying for him, and so forth (NOVA, 1985). Consider the paraplegic, paralyzed from the waist down, and now able to walk because of mind-directed, computer-controlled functional electrical stimulation of the leg muscles (NOVA, 1985). This is now old news.

Consider a blind person who is able to see faint images for the first time in his life because of a computer-based system that literally plugs into the visual cortex at the back of his brain and transmits pictures to the visual cortex that have been captured by a video camera, bypassing the eyes altogether.

Computers also produce some surprising and moving "high tech, high touch" outcomes. Dr. Rena Upitis at the Hennigan school in Boston, Massachusetts relates the story of "one little girl—classified as non-verbal because she had never spoken in school—[who] spoke for the first time at the computer, asking her teacher to come and see her work" (Spence, 1987). In another example, an autistic child was able to be mainstreamed because of the computer's capability as a voice

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1 A couple of years ago this author rented a car while visiting his family in England. At the time of the rental he wondered why the company insisted on a credit card by way of payment. He was “caught” on a camera, without his being in any way aware of it, while driving through inner London. Next thing he knew he received a letter from his rental car company telling him of the fine that had been charged to the rental company by the automated traffic control system, AND of the charge the rental company had imposed on the author to process the fine! What a scam.
synthesizer. "In time," the child said with the computer’s help, “I will utter the truth of my plight. I will remember the people who helped me. I cannot do this without help." Without the computer the child would probably have been trapped forever inside his disability.

"The blind see and the lame walk..." The more aware we become of the many extraordinary computer-based applications that are being designed by inventors and researchers across the globe, the more we can appreciate the relevance of the term computer revolution as an apt description of the transformation that is taking place in every corner of our world.

In schools, computers are making possible the elusive dream of individualized education even as they facilitate collaborative learning and inter-cultural communication. As Melmed (1988) observed long ago: "The application of science and technology, which has had such a powerful effect in other social and economic sectors, can be the basis of a new instructional model with much improved learner productivity."

A last example will suffice to illustrate how modern computer-based technologies are bringing people with disabilities into the mainstream of life today. Yvonne Singer (Fig. 12.7) was born with the umbilical cord wrapped so tightly around her neck that oxygen was denied to her brain for 40 minutes.

The result was cerebral palsy and she has been effectively quadriplegic all her life. Cared for by her family, she has been determined to live as normal a life as possible, which starts with pursuing her education.

Fig. 12.7 Yvonne Singer

The result was cerebral palsy and she has been effectively quadriplegic all her life. Cared for by her family, she has been determined to live as normal a life as possible, which starts with pursuing her education.

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1 From a TV documentary on autism.
2 In Yvonne’s own words: “I have a severe case of Cerebral Palsy, which affects all of my limbs including my vocal cords. Cerebral Palsy is not a progressive disease and it is not contagious. Cerebral Palsy is brain damage. When I was born, I did not breathe for forty minutes because the umbilical cord was wrapped three times tightly around my neck. I did not receive any oxygen to my brain. This caused many brain cells, located in the Cerebellum, to die. These cells controlled motor functions such as standing, walking, feeding, writing, talking, balance, and so on. Due to not being able to breathe, the lower part of my body is spastic. This means that I have contractors in my hips, knees, and ankles. In other words, I cannot straighten out my legs and feet to stand or walk. The upper part of
Thanks to US law guaranteeing all citizens a Free Appropriate Public Education (FAPE) for Students With Disabilities (Under Section 504 of The Rehabilitation Act of 1973), Yvonne graduated from high school and went on to get her Bachelors in Psychology. Then, studying online from her home in New Jersey, she completed her Masters in Psychology and is now teaching, again online, a range of courses in Psychology at various colleges in New Jersey and Pennsylvania.

As Yvonne puts it so well at her website (http://home.att.net/~ysinger): “My name is Yvonne! I am here to say, "Living with a severe physical disability is academically, socially, and career challenging. HOWEVER, SO WHAT! One may have to work ten times harder than the average able-bodied person to reach her or his goals. SO, WHAT! Rome was not built in a day!”

Population Explosion

We cannot ignore the fact that science and technology are enabling people to live longer. Notwithstanding the millions of people who die every year from natural causes, or from accidents, murder, war and terrorism, or from simple disease and famine, the world population is inexorably growing out of control.

China, the world’s most populous nation at over 1.3 billion people, has for a while had a policy for married couples of “One [child] or none.” The sanction for a couple having more than one child has been social disapproval and/or a fine. This worked reasonably well for a while, until China’s emergence as an upcoming wealthy nation. Now, more and more of its people are becoming wealthy enough to decide, based on growing wealth, whether or not they can afford to have more than one child.

In India, the second most populous nation in the world at over 1.2 billion people, there is a policy (not enforced) of “We two, ours two.” In other words, a married couple (two) should have no more than two children. Interestingly enough, this results in most married couples having at least two children, and if the first children are girls, then a third or fourth is likely for the sake of having a more desirable boy, which means, statistically, that India’s population will continue to grow.¹

By contrast, in countries such as Germany and Australia population growth is so slow that the governments of these and other countries in a similar situation are offering incentives to encourage people to have more children.

Advances in medical science, which are significantly enabled by computer-based research and development (R&D) technologies, are resulting in increased life expectancy in all but the poorest, most desperate countries of the world.² Globalization is slowly but surely bringing these poor countries under the umbrella of aid organizations and world philanthropic efforts aimed at rescuing those countries unable to help themselves. Many other still-developing countries like

¹ The optimum number of children per couple in order to maintain population stasis is 2.1.
² For a list of life expectancies around the world, the CIA provides up-to-date information at https://www.cia.gov/library/publications/the-world-factbook/rankorder/2102rank.html
China, India, and Singapore, are rapidly advancing economically, with a consequent rapid growth in a relatively well-off middle class.

Ironically, wealth is a factor that results in decreased fertility. But world population continues to grow. Since the 1940s, the population of the world has tripled—from 2.2 billion to 6.6 billion (Fig. 12.8).

Species Extinctions and Climate Change

Many researchers claim that we are in the middle of a mass extinction event faster than the Cretaceous-Tertiary extinction of 65 million years ago which wiped out the dinosaurs (Endangered Species International, 2008). Endangered Species International blames human activity as a major cause of these extinctions, including activities such as:

- Habitat destruction;
- Invasive species brought into environments by the mobility of human populations;
- Pollution;
- Over-population;
- Over-harvesting.

Climate change is arguably being brought about as a result of human activity. This is a complex subject and not one that can be adequately dealt with here. A reliable source of information is the United States Environmental Protection Agency (EPA). The EPA's Climate Change Site at http://www.epa.gov/climatechange/ offers "comprehensive information on the issue of climate change in a way that is accessible and meaningful to all parts of society—communities,
individuals, business, states and localities, and governments.” Time will tell the degree to which human activity is contributing to climate change; it is, however, becoming increasingly clear that we should not ignore the changes that are going on in our world. Using computer-based technologies to closely monitor the dynamics of global human economic, social, and cultural interactions and the impact of these dynamics on climate change will increase our understanding. Knowledge is power; if we know what is going on, we will more likely be able to take timely action to ameliorate problems before they get out of control.

EDUCATION AND THE INFORMATION SOCIETY

Information Overload

Revolutions create chaos as readily as they bring about change. A significant accompaniment of the computer revolution has been an information explosion that threatens to overwhelm the decision maker at every turn. While too little data, like too little knowledge, is a dangerous thing, so is too MUCH data, otherwise known as information overload.

This problem is not new. Francis Bacon (1561-1626), the English essayist, philosopher and statesman, was perhaps one of the last people who could honestly say: "I have taken all knowledge to be my province." A century later, Voltaire (1694-1778), the French writer and philosopher, was forced to admit that "the multitude of books is making us ignorant." Information overload was definitely a problem in the 17th and 18th centuries, and it is getting worse rather than better, even with the data-processing capabilities of the computer.

This is because the computer can only process data—the raw material of information; you need the human brain to process information. Fig. 12.9 illustrates the Knowledge Spectrum (Debons, 1988), which we discussed in some detail in Chapter 8.
Notice the two segments of the spectrum—the Data Driven and the Cognitive Driven segments. The computer helps us more efficiently handle data processing in the Data Driven segment. Beyond that, it’s up to us to use our mind to make sense of what the computer presents to us. Only then does it have the potential to become information.

Information overload is brought about by advances in technology. In this sense, technology is driven by its own success, like a dog chasing its own tail. Computer hardware and software engineers are increasingly challenged to develop and refine the highly complex systems of control that will allow us to maintain political, economic, and social equilibrium in these technologically turbulent times.

**Information and Wealth**

In a pre-industrial society, the source of wealth was land. Then, in the 18th century the Industrial Revolution caused a shift to capital as a primary source of wealth. Today, information is a major source of wealth. Data is the raw material of information, and processing it effectively is what makes one company more competitive than another.

An increasingly large percentage of the workforce in an increasing percentage of countries earns a living from transmitting, receiving, and processing information. Since 1890, the numbers of those employed in agriculture in the United States, for example, has fallen from 95% of the population to no more than 1% today. Since 1950, the number of those employed in blue collar labor (construction, production, transportation, and so forth) has fallen from 62% to what is projected to be less than 23% by 2012. By 2012, it also is projected that close to 80% of the workforce will be processing data in information-intensive or service-oriented jobs (US Bureau of Labor Statistics, 2004).

This has significant implications for education. As Ogilvy (1993) observes, "What the farm was to the agricultural era, and the factory to the industrial era, educational institutions will be to the information era."

**The Place of Computer-Based Learning in Schools**

In light of this new reality, education is essential for all citizens so that they can contribute effectively and benefit from the wealth that the society produces. Two questions arise:

- To what extent can computers be used to improve the process whereby an individual acquires an education?
- What role will teachers play in "schools" where much of the learning is computer-based?

The myriad computer-based learning applications developed for K-12 education can help release teachers from the primary burden of responsibility for knowledge transfer. Learning, after all, is ultimately the responsibility of the individual student. The teacher, through the thoughtful integration of student-centered methodologies and computer-based technology, can become the facilitator of knowledge acquisition—a knowledge broker, if you will. The teacher's role is to create and sustain an environment in which children can seek, find, and assimilate data, thus becoming informed through the acquisition of knowledge.
Chapter 12: Computers, Education, and Society

The teachers of the future will need intellectual skills of a different kind from teachers of the past. Teachers will still need to know math, history, geography, chemistry, and so forth—they will still need to be educated—but this kind of knowledge will be less important than:

- knowing how to manage a learning environment;
- knowing how to select and set up appropriate individualized learning experiences for children based on their age, propensities, capabilities, and interests;
- knowing how to motivate children;
- knowing how to recognize and work with the subtlest of learning disabilities;
- knowing how to create positive and productive interaction between the child, the school, and the home.

Researchers (Van Dam, 1991), monitoring a classroom where computer-based technology was integrated intensively into the curriculum, noticed that the teacher seemed to have very little to do. The children were working alone or in groups; some with and some without computers. There was a quiet hum of activity; everyone was involved in the learning process. The teacher was attentive to everything that was going on, moving easily from one group to another, sometimes in response to a verbal or non-verbal call for help, other times to more precisely feel the pulse of the learning process as it occurred.

One of the researchers asked one of the 9 year olds: "What does the teacher do?"

"He's very important...," one of the youngsters replied.

The researcher was not satisfied with the response. What did the youngster mean? So the question was put again. "Yes, but what does the teacher do?"

"Well, he's there in case we need him," said the boy, after a moment's pause.

"He's very important... He's there in case we need him..." What a beautiful description of the role of the teacher in the student-centered, student-directed learning environment. The teacher does not direct the entire learning experience. Rather, the teacher sets up and maintains an environment that fosters learning for the student participants. The teacher does not pass on all the knowledge. Rather, the teacher ensures optimal conditions for knowledge acquisition. The teacher is not an officer in a regimented educational system. Rather, the teacher is a "knowledge broker," acting as an intermediary between students and the data that they seek to fulfill their individual information needs.

Children need teachers more than ever in a world where information overload creates confusion in immature minds. But they need teachers less and less as imparters of knowledge, and more and more as imparters of wisdom.

"He's very important... He's there in case we need him..." There is an increasing number of classrooms worldwide where this concept of the teacher as facilitator of learning is a reality, and in many of those classrooms the computer is becoming an invaluable, if not essential, learning tool.
ETHICAL AND LEGAL ISSUES AND COMPUTERS

Many societies today are faced with serious problems regarding the upbringing of their children. This is especially true in the so-called developed world where half of all marriages fail and where, even when the marriages last, both parents feel constrained to work to make enough money to have a decent standard of living. With the best will in the world, parents in such families have difficulty giving their children the care they have every right to expect from the dependable and attentive presence of a nurturing adult. Many children are "latchkey kids," coming home to an empty house and left to fend for themselves for several hours until a parent comes home. Other children come home to a house where the parents have little energy left to respond to their need for attention. Too often, the children are finding at home all the wrong kinds of role models pacifying them hour after hour over largely unsupervised, dubiously educational, TV channels and, much more dangerous, largely unsupervised internet access. As Postman (1986) observed, "We are now a culture whose information, ideas, and epistemology are given form by television, not by the printed word." Shanker (1992) further reminds us that "Studies and statistics—and our own observations—tell us that American families are increasingly fragile and unstable, and we fear that, as a result, many children are being seriously damaged." In a culture where the immediate family appears to have less and less control over a child's upbringing, children need all the help they can get.

In some countries, such as in the kibbutzim (collective farms) in Israel, children are put in the almost total care of specially appointed nurses and educators from a very early age. Today, however, this responsibility is more important than ever. Societies such as those described above are relying more and more on professionally-managed institutions such as schools to act in loco parentis. Acting in loco parentis—in the place of parents—is nothing new for teachers because children have always spent a large proportion of their waking day in school. What, then, are some of the contemporary legal and ethics issues that teachers should discuss with students?

Privacy Invasion

"Privacy," observes Rothfeder (1992), "is an issue charged with emotion. Nothing makes Americans angrier than the suspicion that somebody is looking over their shoulders or peering into their private affairs. And people often describe privacy deprivation with the same words used by rape victims: We say we feel violated, vulnerable and ineffectual." However, Johnson (1985, 1) reminds us that "much to the surprise of many Americans there is no explicit constitutional guarantee to privacy."

But it is a right; we do have a right to privacy. As Philip Zimmerman, the author of PGP (Pretty Good Privacy) points out: "Privacy is a right like any other. You have to exercise it or risk losing it." PGP is software designed to help protect your privacy. It is used to encrypt and decrypt digital documents such as email or other files stored on your computer. The authors of this book

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1 The percentage of households where both spouses work full time is increasing year by year to where it is now nearly triple what it was in 1969 (Source: Bureau of Labor Statistics, Currently Population Survey, 1999).
have made available a tutorial to teach you how to download a free copy of the software from the Web and how to use it. The tutorial can be found at http://www.pitt.edu/~poole/PGPintro.htm.

All over the world, the institutions established by government for the maintenance of law and order, along with most major and many minor corporations and private investigative agencies, use technology to an ever-increasing extent to spy on people. Surprisingly enough, most of the spying is legal, either sanctioned by law or at least not proscribed by it—which does not necessarily make it right. On the other hand, some of the spying is illegal, but because we do not know it is going on we do not become concerned.

Is ignorance bliss, in this case? Do our students need to be sensitized to the reality of privacy invasion? Is there any harm in it anyway, especially if one is behaving oneself? And in any case, is there anything we can do about it?

When it comes down to it, as Rothfeder (1992) points out, "It's an information free-for-all, and even people with little computer expertise can get [most any data they want]." The problem is that in many instances we are content to have our privacy invaded. Hospitals need to keep a record of our medical history so they can more efficiently take care of us when we need treatment. Banks need to keep a record of our accounts so they can help us manage our hard-earned money.

Ultimately you can best control invasion of your privacy by being sensitive to the fact that it does go on more than you think. That awareness alone will give you a healthy skepticism whenever you are in the situation where you are asked to divulge personal data. As teachers we should also help our students to become sensitive to this negative side to the otherwise predominantly positive social change brought on by computer technology.

The United States Government as long ago as 1966 passed the Freedom of Information Act which, in tandem with the 1974 Privacy Act, ensured controlled public access to any database maintained by the federal government. To be more specific, the Freedom of Information Act opened up governmental databases to public scrutiny while the Privacy Act limited access by making it dependent on the permission of the individual whose records were to be made available.

Meanwhile the Fair Credit Reporting Act was passed in 1971 to protect people's rights of access to data gathered by the financial credit reporting industry. The Family Educational Right and Privacy Act of 1974 guaranteed public access to student reports in the files of federally-funded educational institutions. The Right To Financial Privacy Act of 1978 prohibited federal government access to banking records without either the permission of individuals who are the subject of the search or a search warrant. Other similar legislation has been passed, and there will be more to follow as situations arise in which individual freedoms are violated in more and more creative, and no doubt computerized, ways. Ethics continues to plod along in pursuit of science.

**Computing Inequities: The Digital Divide**

Rich versus Poor "For computer-based knowledge to become an extension of a human mind, that mind must at least have access to the technology. The poor will not immediately have such access, placing them at a ... disadvantage" (Madron, 1985). Pillar (1992) describes "the creation of the technological underclass in America's public schools." "In 1984," he notes, "white children used computers in elementary and secondary schools at about twice the rate of African Americans"
and Hispanics. By 1989," Pillar writes, "according to the U.S. Bureau of Census, nearly the same percentages of those three groups [White, African American, and Hispanic] used computers in high schools. Elementary schools also made dramatic progress. And disparities between rich and poor and between public and private schools seemed to narrow just as sharply."

But Pillar was skeptical of the relevance of the United States Bureau of Census statistics and decided to see for himself what was going on in the schools. His findings were somewhat discouraging. "I visited inner-city, rural, and suburban schools in various parts of the country," he wrote, "and after discussions with scores of teachers, students, and school administrators, an inescapable conclusion emerged: Computer-based education in poor schools is in deep trouble. Not only did these schools lack the funds and skills to finance the maintenance of their computer hardware. They also lacked the training to make the best use of the machines. "In most cases," Pillar concluded, "computers simply perpetuate a two-tier system of education for rich and poor."

Right now there are pockets of privilege, so to speak, among the poorer school districts where forward-looking parents, administrators, and teachers, sometimes sponsored by local business and/or by one or other of the major personal computer manufacturers, have taken on the challenge of providing the best possible educational opportunity for the children. The key ingredient of success has usually been the driving force of significant individuals who have galvanized the community and done what is necessary, through grants and donations, to make computer-integrated teaching a reality in their schools.

Unfortunately, however, there are still many school districts, even in the United States, where a half-hearted acceptance of the value of suitably integrated educational technology, tempered to some extent by economic realities, have resulted in children being denied the opportunity to share in the benefits enjoyed by the privileged few. There is hardly a school in America today that does not have computers for student use; every year the ratio of students to computers improves in the students' favor. Yet, as Pillar (1992) observed, many of the machines in the poorer schools are used "so rigidly and ineptly as to repel students."

**Girls versus Boys** Women continue to suffer from stereotyping which casts them in the mold of the technologically inept. The problem pervades our social institutions, starting with the home and continuing in school. Sanders (1987) observed that "girls and boys use the computer equally when they are required to in class, but as soon as they're allowed a choice—such as after school or in elective computer courses—girls see that boys take advantage of the opportunity far more often than girls do. This reinforces the notion that computers are a male thing."

Jo Sanders has written a 2005 review article (Sanders, 2005) titled: “Gender and Technology: A Research Review” in which she reiterates the sad fact that women continue today to be underrepresented in the field of information and communication technology (ICT). This belies the evidence from extensive research which strongly suggests that girls are at least equal to boys in tasks that involve communication skills and skills related to math and problem-solving. The problem is one of opportunity.

Dorothy Ellen Wilcox (1996), in her Masters Thesis at the University of Alaska titled “Computers and the Internet: Listening to Girls’ Voices,” presented her findings that girls do need help in
overcoming the cultural stereotype that causes them to be less inclined towards technology-based careers than boys. In her conclusion, Ms Cox had this to say:

“Instead of socializing girls toward passivity and docility, non-hierarchical technology like e-mail and the Internet has the capability to assist communication and provoke development of the ability to critique the status quo among adolescents. Education is not apolitical; the curriculum masks prevailing politics and power as natural and results in their maintenance. Freer access to materials that reveal the inequities of power relationships and allow adolescents to unmask and unpack gender and racial issues will encourage debate and nourish the formulation of students' critical cognitive skills. I see educational technology as a vehicle that can initiate and nurture such dialogue, and in doing so, set the stage for inevitable change. In the faceless culture of computer-mediated communication, skilled young people will be able to pass as adults and elucidate their own concerns. Girls who are educated to an activist stance will feel comfortable participating in the networked communications web. After that, they will not need adults to interpret their words; electronic mail and the internet will become the means they can use to speak for themselves.”

Cynthia Lanius, Executive Director of the Center for Excellence and Equity in Education at Rice University, quotes a report of the National Science Foundation which found that “Degrees awarded in computer science decreased among both men and women from 1985 to 1995, and women went from earning 36% of those degrees in 1985 to only 28% in 1995.”

“The problem’s repercussions are staggering,” she goes on to report. “The Bureau of Labor Statistics lists computer scientists, computer engineers, and systems analysts as among the occupations with the fastest employment growth, 2004-2014. Teachers working with high-school students using technology observe that, in general, girls don't seem to be as intrigued by computers as boys are.” The full GirlTECH report: “Getting Girls Interested in Computers” can be read online at http://math.rice.edu/~lanius/club/girls.html.

The following are examples of the kinds of strategies that can help to overcome the stereotypes that perpetuate the computer gender gap (Table 12.1).

### PRINCIPLES OF COMPUTER EQUITY

- Focus specifically on girls.
- Target girls in groups.
- Design activities around girls' existing interests.
- Stress the usefulness of computers.
- Eliminate biased computer practices.
- Pay attention to your software.
- Let others know.
- Do it again next year.

Table 12.1 The Principles of Computer Equity

Courtesy Jo Sanders
Whites versus Minorities  It seems absurd to have to point out that the color of one's skin makes no difference whatsoever with regard to one's level of intelligence. This author’s experience teaching in schools K-12 in Europe, Africa, the Middle East, and North America has taught him that the range of intelligence among these diverse cultural and ethnic groups is the same. Those who believe otherwise should be helped to recognize one simple fact: that they are guilty of inexcusable prejudice born of unfortunate cultural bias.

Such bias continues to plague our social structures in general, and our educational institutions in particular. African Americans and Hispanics are not expected, and often do not expect themselves, to achieve success in technology fields such as those associated with computers. Much of the problem is that children in these ethnic groups are more likely to come from families living below the poverty line, which translates into a lower likelihood that these children will either attend schools in the wealthier, more technology-rich districts, attend school on a regular basis, or graduate from high school.

The Lack of Equal Access to Information  Since knowledge is power, and since not all children have equal access to information because of disparities in the funding and management of different school systems, then it stands to reason that many children are at a serious disadvantage. They are on the wrong side of the Digital Divide. Some students are fortunate to attend schools where they have access to libraries of electronic data in the form of interactive text and video, with quality educational software to complement other forms of instruction, and with open lines of communication between themselves and students in other schools at home and abroad. These fortunate students are also more likely to have their own computer at home, with on-line, multimedia encyclopedias and access to the Web. Such privileged students will be more likely to receive a more rounded and comprehensive educational experience than students attending less technologically-endowed schools.

SECURITY: HACKING AND CRACKING

Hacking  generally describes the activity of computer aficionados who become absorbed with the challenge of pushing computer technology to the limits of its capabilities. The term "hacker" is not per se pejorative. Indeed, it started out as a term of endearment to describe lovable and often "nerdy" individuals who were recognized as benefactors to society because of the innovative computer-based solutions which they created. Hackers were programmers and visionaries. In the mid-1970s these benevolent hackers formed an informal association called the Home Brew Society which included in its membership people like Steve Jobs and Steve Wozniak, who founded Apple Computer Corporation.

Today hacking is generally frowned upon because the term has come to be associated with practices that involve individuals who use computer technology to break the law, specifically to violate the security or privacy of computers and networks. The term used to describe criminal

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1 In chapter 8 we discussed online data base retrieval services such as DIALOG Information Services' CLASSMATE™ instruction program.
2 There are also "good" hackers, who try to anticipate or decode the actions of bad hackers. These are often employed by governments and by companies that create anti-virus applications.
hacking—cracking—was in vogue until "crack" and "crackers" became identified with other social ills not related to computing. In the next several sub-sections we will briefly describe the kinds of criminal hacking of which teachers and their students would do well to be aware. Few of our students will ever be guilty of criminal hacking, but many of them will be victims of it.

**Computer Viruses and Other Malware**

Computer viruses are programs created by hackers. As their name implies, viruses infect other computer systems by attaching duplicate copies of themselves to legitimate operating system or application software with which they come into contact. They are carried from computer to computer either indirectly by way of storage devices (like the currently popular *flash* drive), or directly by way of e-mail attachments and downloaded software.

Any computer virus should be taken seriously. Most viruses are designed to do some kind of damage to a system either by destroying data or otherwise compromising a system's operations in such a way as to make it unusable. Other viruses might appear to be "harmless," perhaps causing a funny face or announcement to appear on the screen at some programmed date and time. But "harmless" is a relative term. Anything that interrupts normal computer operations is cause for alarm because there is no telling what else might be going on in the background, unseen on the computer screen.

Computer viruses are activated in various ways. **Time bombs** are so-named because they are programmed to "go off"—start doing the damage they have been programmed to cause—at a certain time on a certain date (a popular date is Friday the 13th). **Logic bombs**, on the other hand, are usually less predictable because they are triggered when some specific set of switches (bits) inside the computer's memory become electronically set to a predetermined value.

There are now hundreds of decidedly harmful computer viruses capable of anything from changing or destroying data, slowing down or even immobilizing a system or network, or interfering with the system's interaction with peripheral devices such as the screen or printer. One common and annoying virus attacks the Macros that run inside of many Microsoft documents. They may, for example, make all subsequently opened files "Read Only" or "invisible" to *Word* itself. Such viruses spread quickly from home to school and hence throughout a school's network.

**Malware: Worms and Trojan horses**

**Malware** refers to malicious computer programs that are run on your computer without your knowledge. A special type of malware, called a **worm**, is a program designed to duplicate itself not only from machine to machine, but also *within* each machine, effectively overwhelming primary memory with copies of itself and leaving no room for any other programming activity. As it does so, it deletes targeted file extensions or causes a program to overwrite its own code with nonsense code, often targeting those programs that are essential for the operation of the system itself. Moreover, a worm will often reply to unread messages in an e-mail reader (*Outlook Express* or *Microsoft Exchange*, for example), spreading itself quite handily and looking like messages from YOU. Worms will often masquerade as .zip files, media files (.mp3, .gif) or other file attachments. They are activated, or "installed," by opening the attachment.
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An infamous worm called the Slammer was launched at 12:30 am EST on January 25, 2003. Within 15 minutes it "brought down the Internet," causing significant damage to the targeted SQL mega-databases that coordinated global digital commerce. The identity of the hacker is not known, but the effects of the Slammer are known: over $1 billion in lost revenue worldwide. (Boutin)

Another specialized category of malware is the Trojan Horse, named after the innocent-looking giant wooden horse built by the Greeks to gain covert entry inside the walls of Troy. The computer version of the Trojan Horse is a program which looks innocent enough--perhaps a computer game made available on the Internet and often an e-mail attachment--but which has code built into it which inflicts damage of one kind or another once installed on a computer system. This can range from destroying files to altering the appearance of your Desktop. Trojan Horses that are designed for e-mail distribution will generally then attach themselves to messages you send by way of your Address Book.

Spyware and Spam

Although there is some disagreement about when viruses leave off and malware begins, it is generally agreed that spyware are hidden malware that sit on your computer and gather information about your computer use, preferences and data without your consent. Although often created by paid or contracted programmers, spyware programs are of questionable legality. They can also be sinister, establishing a sort of "remote control" over your computer or browser, or logging, and communicating, all of your keystrokes (and thus your passwords and credit card numbers). Spyware presents a serious threat to individual and network privacy and, as such, is currently one of the most actively combated forms of hacking. Spyware also causes problems on the host computer, generally slowing performance, due to the large information files that they create and distribute behind the scenes.

Adware is another pest, a subset of spyware causing pop-up advertisements to appear even when you are not actively surfing. These are the result of a spyware application that communicates your Internet searching and computer activities to advertisers and others interested in such data, who send you pop-up ads geared to your "interests." There are numerous other forms of malware. They are well logged at PestPatrol Pest Research Center (http://www.pestpatrol.com/pestinfo).

Spam is another form of malware that is becoming more of a problem than a pest. This unsolicited e-mail is often advertisements, but can also be "pornspam." Clearly, schools want to block both categories. Although there is new federal legislation to reduce and, to some extent, monitor spam, this is malware virtually impossible to police by policy. Keeping alert to and reporting spam (but not opening it!) is yet another responsibility of the computer-using teacher.

Trespass of Computer Systems

This is one of the seemingly innocuous yet potentially most devastating activities carried on by modern day hackers. Skilled hackers are able to obtain the access codes and passwords of institutional computer systems ranging from the local hospital or university to the Pentagon and beyond. The networked world is an open door to hackers determined and skilled enough to get around the various levels of security designed into the systems. Some hackers are motivated purely by the thrill of being able to gain access to these systems; they have no intention of
damaging the data stored in them, and no particular interest in the data per se. But the activity is still illegal because it is trespass, an invasion of privacy, and an infringement of peoples' rights.

Other hackers go further, altering data, stealing data, destroying data, or adding data. Sometimes the objective is sabotage, sometimes espionage, sometimes thrill-seeking vandalism, and increasingly it is identity theft. Sniffers are programs written by hackers for the purpose of capturing id names and passwords as the data packets travel across a network. Criminal prosecutions have been brought against a number of such hackers in the last few years.

When the hacker is working from a foreign base and infiltrating US government computers via satellite, the potential for disaster is real. Such was the case in 1988 when a hacker tapped into NASA computers. Fortunately, a NASA computer scientist discovered the intruder early on and, in order to track him down, set up elaborate monitoring procedures which kept NASA apprised of his every move. Eventually the hacker was traced back to West Germany. No serious damage was done.

But it is not only outsiders that breach the security of networked computer systems. Kabay (1992) reminds us that "75% to 80% of all attacks on data confidentiality and integrity are by employees authorized to use the systems and networks they abuse." Much of this in-house hacking, even when detected, goes unreported because companies fear loss of reputation and credibility in the eyes of the public, in much the same way as banks are loath to report that they have been victims of electronic embezzlement.

Similarly, schools will often deal with hackers quietly and in-house. It is helpful, therefore, for a school or district to have a strongly worded, legally viable, and clearly stated policy spelling out the consequences of hacking by students or employees.

**Money Theft (Embezzlement)**

The bill paid by banks for electronic fraud runs into the billions of dollars per year. The banks, of course, pass the bill on to the consumer. If the bank goes under, the tax payer picks up the tab. What Kabay (1992) has to say about network infiltration applies equally to electronic fraud: most of the theft involves company insiders--"white-collar criminals." The last thing the banks used to want was that their vulnerability to financial loss through credit card fraud and illegal transfers of funds should become public knowledge. Thus much of this kind of crime used to go unreported. Today, however, electronic embezzlement is so rampant that financial institutions are openly and diligently investigating cases when they are detected.

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**STEPS SCHOOLS SHOULD TAKE TO SECURE NETWORKS AND COMPUTERS**

As long as computer networks are vulnerable, hackers will attempt to breach them. The responsibility lies with the designers, builders and managers of these systems to make them as secure as possible against unauthorized entry. This is a mammoth task because networks are communications systems; access is the key to their success. Moreover, even the best computer system and productivity software leaves "holes" through which hackers can gain entry.

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1 In schools, this is often salary, grade and testing data!
The only way to fully protect a computer is to turn it off and/or disconnect it from the network, which is clearly not a viable solution in most cases. However, there are several things teachers and schools can do to combat these menaces, in addition to adhering to the Software Code of Ethics.

- The foremost solution is the purchase and installation of reliable up-to-date anti-virus software, such as that marketed by McAfee and Symantec corporations. In a school, both the network servers and all client machines, including portables, should scan hard drives, external and portable storage devices, all installations, downloaded applications and files, and all e-mail messages without cease. Virus "definitions" are kept up-to-date and made available at the website of the anti-virus producer; they should be automatically downloaded to all computers.

- Select an e-mail service or client that provides a spam and virus filter. These will generally either delete questionable messages, mark them, or route them to a discrete folder.

- Special software exists to detect and remove spyware and trojan horses. It is strongly suggested that a school obtain more than one such application, for none will do the full job. It is also possible to access an online anti-spyware service, which will scan and repair your hard drive via the Internet (with subsequent advertisements for the full version of the software).

- "Cookies," a common and generally benign form of spyware, can be manually deleted from within every web browser. Browsers can also be set to "deny cookies," but this has the consequence of making it impossible to access many of the newer websites.

- The school network should be sure to have an active firewall, which will help it to detect and log attacks to its security. Often these take the form of random, or purposeful, flooding of the IP address with requests; if that flood reaches critical, the network server can shut down.

- System and productivity application producers make "fixes" available constantly online, necessary generally to close "holes" attacked by hackers. All school computers should be able to download and install these fixes as they become available.¹

- Educate yourself and the school community to a few simple rules:
  - Change passwords often and make them as random as possible;
  - Do not store passwords or financial information on the computer;
  - If you use the computer for financial transactions, do so only from a Secure Site (SSL) option;
  - Because many viruses are spread over e-mail attachments, it is a straightforward solution to delete without opening any e-mail message and/or attachment

¹ There was a time when Macintosh computers and systems were viewed as "immune" to viruses. This is no longer true. Not even the open source systems are immune these days.
Chapter 12: Computers, Education, and Society

from an unknown source. By setting your e-mail application to "delete attachments with original message" you can further protect yourself;

  o Be alert to any sudden change in the performance or appearance of your computer(s). Report anything odd to network services immediately.

• It is wise also for a school's IT staff to keep all members of the school community informed of new viruses. Such information will sometimes be bogus (there are virus hoaxes quite often), but an ounce of prevention is worth it!

Moreover, networked schools of the future will have to implement the kind of steps recommended by Kabay (1992) to protect corporate networks. Here are Kabay's recommendations to network managers:

• Have a message displayed at the network log in that warns hackers that the system is for authorized users only and that intruders will be prosecuted. If you do not use such a log in, consider implementing it.

• Have a written plan of network security procedures describing standard operating procedures including counter measures and defense plans for when the network is under attack.

• Make access controls and event logging (maintaining a record of all use of the network) part of this standard procedure.

• Regularly go over the procedures with personnel responsible for system security.

For wireless networks, it is possible to restrict network access to only those MAC addresses that are logged with the network server. Furthermore, all modern networks can be remotely managed. Network attacks and problems often occur after hours; if the managers can be alerted to attacks and then scan, repair and reboot network servers from their homes or laptops, the institution itself will be more secure.

This might read like overkill for many school teachers and administrators, especially in these early days of networked computing in schools k-12. However, computer managers at any college can relate a litany of horror stories that are the result of abuse of computer systems by that minority of students with a personal or societal axe to grind. Remember, trouble most often comes from inside.

A Final Note About Passwords

It goes without saying that protection of personal passwords is essential. You will remember that we advised teachers earlier to teach students not to share passwords. Well, this is even more important for teachers. Further, teachers, who are often somewhat uncomfortable with technology to begin with, often take security protection casually, storing their passwords in a desk drawer or taping them to the computer itself. Many use easily guessed passwords, such as their own names! Some IT departments contribute to security laxity by assigning all teachers the same password for

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1 You will remember that each hardware device on a network has a discrete and unique digital address. In this case, the MAC address is on the wireless NIC cards in the laptops.
grade report, attendance, and other network operations. How hard do you think determined students have to work to "hack into" these files, to access and even copy teacher applications? It is unfortunate that caution has to reach into schools, but it is a fact of life. The wise teacher follows the guidelines in this chapter for her personal computing life – and keeps her computer out of the hands of her students!

LOOKING BACK
This chapter has briefly examined the impact of computers on society. Computers have been incorporated into every product under the sun. They have been woven into the fabric of our systems of transportation, administration, information, communications, manufacturing, finance and government, to name but a few. They have begun to transform the way we live, the way we work, and the way we play. Inevitably they are being slowly but surely woven into the fabric of our education systems, too, and they will transform the way we teach and learn.

This chapter also has argued the case for incorporating into school curricula the discussion of the computer-related ethical and legal issues raised by new technologies. James Truslow Adams pointed out that "There are obviously two educations. One should teach us how to make a living, and the other how to live." Schools should prepare children to address ethical and legal problems when ignorance of them will leave students vulnerable to victimization of the kinds described in this chapter.

Sanders (1986) observed that we can restrict ourselves as teaching professionals to the narrow task of working within the framework of the narrow academic responsibilities that are assigned to us, or we can extend the scope of that commitment to include the parental, counseling, and leadership roles which our students need more than ever today.

The question every teacher must address is this: "Is it fair that just a few of today's children are already enjoying the advantages that computers, used appropriately, can bring?" The objective of this book is to open a window onto the classroom of tomorrow. This classroom is already available for a privileged few; we must ensure that it is available to all.

When they graduate from school, our students will function more effectively if they protect themselves against the unfair competition that comes with privacy invasion. On the personal level our students must learn to be conscious of, and give due recognition to, the privacy and equality rights of others. Girls, in particular, must learn to protect themselves against unequal opportunity arising from a prejudicial stereotype that women lack technological competence.

Stealing software is both easy to do and easy to get away with. Hacking is not so easy, but it presents an irresistible challenge to bright, determined, morally-indifferent individuals who need the boost to their egos that comes with the exercise of the power that their computing skills put at their fingertips. Unfortunately they do not feel constrained by a code of ethics that respects others' security and privacy rights.

The more we understand the realities of the computerized world, the more fully we will be able to function in it. This chapter has discussed software piracy and hacking in some depth not simply because they are interesting to learn about. It is part of our role as teachers to make our students
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aware, on the one hand, of the constraints on their freedom dictated by the rights of others and, on the other hand, of the extent to which their own rights can be infringed upon by the unethical and/or illegal activities of the kind described. Our students almost certainly will be victims of hacking. They may even be among the few who find these activities "bait which [they find difficult to] resist swallowing." The knowledge that you help them acquire by discussing these issues with them will serve both them and society well

LOOKING FORWARD

Chapter 13 examines an important aspect of technology's impact on society: the growing number of accessibility options available to people with disabilities. The computer offers the promise that, eventually, even children with severe handicaps will be able to enjoy the benefits of a free and appropriate public education (FAPE). FAPE is still a dream for many children who have a disability, notwithstanding the Education for All Handicapped Children Act of 1975, which gave such children the right to a free appropriate public education. Chapter 13 examines this and other equal rights law in light of the needs of people with a disability, and reviews efforts that are being made to create a fairer world for all.
Chapter Thirteen
Reflections on Education for an Information Age

What avail is it to win prescribed amounts of information about geography and history, to win ability to read and write, if in the process the individual loses his own soul...if he loses his desire to apply what he has learned and, above all, loses the ability to extract meaning from his future experiences as they occur.

John Dewey (1859-1952)

A teacher is a person with a touch of immortality, and he should be most envied among men. His profession should be the most sought after, the most carefully prepared for, the most universally recognized.

Samuel Gould

The mind, stretched by a new idea, never goes back to its original dimension.

Oliver Wendell Holmes (1809-1894)

LEARNING OUTCOMES

Chapter 1 of this book presented some of the conclusions drawn from the research into the effectiveness of computer-based teaching and learning. Many of those conclusions, while tentative, are sufficiently impressive to justify the introduction and use of computers in classrooms where they have been thoughtfully integrated into the learning process.

Computer-integrated education works best when it is well-planned, well-integrated, closely monitored as to its effectiveness like any other methodology, and given a fair chance. "A fair chance" can only be guaranteed if computer-based teaching and learning is constructed on the seven pillars of success. We will discuss these pillars of success in the conclusion to this final chapter of the book.

The major educational theories and methodologies have timeless merit and are still applied in classrooms today. After all, as Confucius said: "The nature of people is always the same; it is their habits which separate them" (Fersh, 1982). It will be interesting to see what pedagogical "habits," if any, need to be changed when computers are factored into the learning equation.

How might traditional theories of learning be best applied? What are some of the mistakes made by teachers when using computer technology? What help is available for teachers who are new to using computers in the classroom? What is the future for schools if the integration of technology-based education continues at the present pace?

These are some of the questions addressed in this chapter, which will cover the following topics:

- Computers, learning theory, and cognitive development
  - Computers and learning
  - Learning theory
Chapter 13: Reflections on Education for an Information Age

• The Importance of Individualized Education
• Caveats regarding computer use in the Classroom
• Computer-Integrated Teaching and Learning: The Ten Pillars of Success
• Taking Care of the Teachers
  • Teachers must have time
  • Teachers must have ongoing training
  • Teachers must have logistical and technical support
• A Final Word from John Dewey

COMPUTERS, LEARNING THEORY, AND COGNITIVE DEVELOPMENT

Computers and Learning

The computer is a general purpose machine. Indeed, as you may recall, Alan Turing (1937) demonstrated that it is in theory a "Universal Machine." You may recall from Chapter 2 that John Vincent Atanasoff, the inventor of the electronic digital computer, had educational goals in mind when he invented his machine. With the application of human intelligence, the computer is becoming a useful tool for a diverse set of learning tasks, from reading and writing, to doing math, monitoring attendance, simulating scientific experiments and social conditions, enabling handicapped children to join the mainstream of education on equal terms, to name but a few.

Educators have been quick to imagine ways in which the computer can be programmed to foster the learning process. This was true as early as the 1960s, when computers were mighty, multi-million dollar behemoths owned only by governments and major corporations. A few enterprising teachers were linking up with these corporations and shepherding students across town to give them the opportunity to develop problem-solving skills by writing programs.

Bill Gates and Paul Allen (Fig. 13.1), co-founders of Microsoft Corporation, first learned to program as teenagers in the 1970s on a DEC PDP-10 at the University of Washington¹.

Fig. 13.1 Bill Gates (standing) and Paul Allen in the early days

¹ Computer-Schools.us, 2003
From day one, computers have been important research tools, especially for scientists and engineers. By the late 1960s these latter were joined by researchers in all fields of learning when database management systems (DBMS) enabled the easy storage and retrieval of huge amounts of text-based data (Date, 1986). The descendants of these DBMS are the engines driving multimedia and distance learning computer systems today.

So computer use in schools is not new. The question is: Is its use founded on sound pedagogical principles? Before we answer that question, it will be useful to review the various ideas about learning and cognitive development that guide teachers when they formulate methodologies for helping students in their acquisition of knowledge. After all, decisions about how and when to use computers to improve the quality of a child's education must be predicated on the knowledge and experience of the teachers responsible for preparing and maintaining the environment in which that education takes place.

**Learning Theory**

How children *learn* has been the topic of much debate and is naturally an important subject of study for teachers. There is no one best approach to enabling learning that can be applied in all situations with all students (Bigge, 1982). For this reason, student teachers who are well-prepared for the classroom are expected to study, experience, and apply (at least in a laboratory setting such as in-course simulations, or during field experiences and student teaching) a range of learning theories. Study of the theory of education is designed to help teachers become familiar with a body of research in order to inform their application of teaching methodologies so that students have the best possible learning experience.

**Cognitive Development** There is a significant body of research that helps us to assess our students' academic standing in relation to cognitive developmental based on variables related to their age and intellectual maturity.

Jean Piaget (Fig. 13.2) philosophized that children construct their own sense of the world based on their experience.

![Jean Piaget](image)

**Fig. 13.2 Jean Piaget (1896-1980)**
Specifically, Piaget (1954, 1971) observed that all children follow a progression towards intellectual maturity, from the initial sensori-motor stage (birth to 18 months/2 years) to the symbolic or pre-concrete operational stage (18 months to 7/8 years) to the concrete operations stage (7 years to 12 years) and finally to the stage where the child becomes capable of formal operations (12 to 15 years).

Jerome Bruner (Fig. 13.2), who studied with Piaget in Switzerland, acknowledged Piaget’s work when he refined the stages of human cognitive growth, noting the progression in the ways children "represent their experience of the world."

This progression goes from the enactive mode (where actions are the byway to understanding), to the ikonic mode (where images are used to represent experience), and finally to the symbolic mode (where language in its many forms enables cognitive understanding and expression of reality). These three modalities of learning, while sequentially acquired by young children as they grow, are also applied by adult learners as they continue to learn throughout their lives.

Lev Vygotsky (Fig. 13.4) sees the learner as willingly active in the pursuit of an individualized understanding of experience.
Driven by curiosity about a world which in real terms expands with this experience, the learner seeks answers to questions as they arise: What is this? Where is this? What will happen if I do this? Who is this? and so on.

Finding answers to this constant stream of curiosity-driven questions involves the learner in equally constant, though not necessarily productive (i.e. effective, or correct), construction of mental and physical solutions. As Perkins (1991) observes: "Central to the vision of constructivism is the notion of the organism as "active"—not just responding to stimuli, as in the behaviorist rubric, but engaging, grappling, and seeking to make sense of things."

A key component of Vygotsky’s philosophy of learning is the Zone of Proximal Development—a zone around the child in which other agents (family, friends, neighbors, culture) and environmental artifacts (toys, animals, local geography, climate, to name but a few), inevitably impinge upon the knowledge base constructed by a child. Teachers, too, along with a student’s peers, are in the “zone of proximal development,” where guidance and collaboration augment the child’s natural and independent development. It is the rare child, after all, who can "discover" unaided the skills required to contribute effectively in today's information-intensive world.

Perkins (1991) echoes the philosophy of Jean Piaget (1971), who views scientific knowledge as stemming "neither from sensation nor from perception alone but from the entire action..." Piaget notes that "the characteristic of intelligence is not to contemplate but to "transform" and its mechanism is essentially operatory. ... We only know an object by acting on it and transforming it..."

Good teachers, constructivist or otherwise, given an environment in which they can allow free rein to a child's thirst for understanding, will try to focus the child's quest by providing appropriate stimuli and feedback. The teacher's goal in this collaborative endeavor is not so much to instruct as to educate—*educere*, lead forward—in the belief that the child should not be left to flounder in the discovery of knowledge.

Unfortunately, most teachers are not given "an environment in which they can allow free rein to a child's thirst for understanding." Classes are typically too large to accommodate significant individualized instruction. For this reason constructivism, and the many other powerful theories of learning such as those advocated by Dewey, Montessori, Piaget, and Bruner, have been paid no more than lip-service in public, or even most private, systems of education.

However, teacher-pupil ratios are falling, and technology is becoming sufficiently sophisticated to take on more and more of the functions of guided individual student learning. This evolutionary process is showing promise of eventually leading to a learning environment in which teachers—rather than being the source of knowledge—will manage, guide, motivate, and coordinate. Students will actively, individually or in small groups, discover knowledge in the context of the Montessorian "prepared environment" of the technology-rich classrooms of tomorrow.

This is already happening in a fair sprinkling of schools worldwide, including some of those profiled in this book. But let us examine more closely the importance of individualized education in general and, more specifically, the impact of the ideas of Doctor Maria Montessori in the realm of individualized education.
THE IMPORTANCE OF INDIVIDUALIZED EDUCATION

The extent to which individuals reach their potential as human beings is partially dependent on cultural expectations. The history of education tells the unfortunate story of the many systems that operated under the assumption that certain groups of individuals were less academically able than others. This attitude was able to persist because the education systems themselves were founded on arbitrary definitions of what constitutes "academic ability."

To some extent this is understandable, even though it is inexcusable. As explained in the previous section, education has a pragmatic emphasis—where success is measured by how profitable the graduate becomes in adult life. But a more appropriate and equitable definition of academic ability begins with the assumption that every individual is academically able, regardless of whether that ability will yield a profitable return. The school's responsibility is to determine in what respects this is true for each and every student. As one teacher put it: "The question is not how smart the child is, but how the child is smart."

The school as lifelong information system succeeds or fails to the extent that it helps individual students achieve their potential as human beings. "You cannot teach a man anything," observed Galileo; "you can only help him to find it within himself." We may look to numbers as a measure of performance because we have no more convenient way of judging success. So we rate schools and individuals based on numerical criteria. But in the end, true success can only be measured in terms of the individual's self-fulfillment.

Education must therefore continue to broaden its definition of what constitutes a successful student, for no two graduates should be expected to be equally or identically affected by what goes on in schools.

Each individual has a unique and valuable contribution to make. Education's task—with the help of students, parents, teachers, administrators, and the local community—is to nurture the unique excellence in each and every one of us. Traditional methodologies developed to cope with large group instruction tend to overlook individual needs. The underlying argument of this book, however, has been that individualized education is more likely to be promoted in classrooms where teachers are given the opportunity to design and maintain resource-rich, computer-integrated learning environments.

The computer thus can be the key that opens the door to individualized, student-centered, constructivist learning. Let us examine this more closely, and then consider some caveats about the use of computers in the classroom.

When Should the Computer Be Used in the Classroom?

The human mind is extraordinarily complex. Tufte (1990) captures this complexity when he describes the information processing skills of the human intellect:

"We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, structure, highlight, group, pair, merge, harmonize, synthesize, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, refine, abstract, scan, look into, idealize, isolate, discriminate, distinguish, screen, sort, pick over, group, pigeonhole, integrate, blend, average, filter, lump, skip, smooth, chunk, inspect,
approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flip through, browse, glance into, leaf through, skim, list, glean, synopsize, winnow wheat from chaff, and separate the sheep from the goats."

It is unreasonable to expect children to grow intellectually in some straightened environment where variety of learning experience is reduced to the bare minimum. This is something that a good teacher intuitively understands. But the good teacher also intuitively understands that effective learning requires discipline, concentration, periods of peace and quiet, and a sense of order.

Unfortunately, it is often easier for a computer to be used as a pacifier than as a tool for solid learning. Many applications of computers in schools today have the primary objective of occupying the children for a period of time, regardless of learning outcomes. In light of this it will be useful to examine when and how the computer should and should not be used for teaching and learning.

While it is never indispensable, the computer is an appropriate tool to use for teaching and learning. Here we will review a sample selection of such situations.

**Computer-Based Learning Enables the Teacher to Tailor the Learning Situation to Suit Individual Student Needs**

Turkle (1984) recognizes the value of the computer, "the second self," for those many learning situations where the child's personality, age, and style of learning calls for an individualized approach. This puts the onus on the teacher to diagnose each individual child's information needs and style of learning, and then prescribe appropriate learning opportunities.

While not impossible, this is difficult to do in a traditional classroom where the large class size coupled with a limited set of learning materials makes customized instruction an elusive dream. In the computerized classroom, however, access to a wide variety of educational software enables the teacher and student together to select effective computer-based learning situations, especially if the teacher has the training, experience, and motivation to know each child well.

There is no substitute for this. As Jean Jacques Rousseau observed in the preface to his 1762 novel *Emile*: "The first thing is to study your pupils more, for it is very certain that you do not know them." While it is true that children will apply themselves diligently when their mind is engaged, it is not true that, unassisted, they will always select activities that will further their education. So they need the teacher's help.

**Computer-Based Learning Suits Children's Desire to Control Their Own Learning**

Piaget (1926) observed that at least up to the age of about 7 children are essentially egocentric in their thinking, and therefore also in their use of language. As Piaget states: "The functions of language are complex, and it is futile to attempt to reduce them all to one—that of communicating thought .... For the most part [children up to the age of about 7] are only talking to themselves." A corollary of this, with pertinence to the importance of well-programmed computer-based learning, is the idea that, as Piaget puts it, "The audience is there simply as a stimulus" (emphasis added).
The methodologies applied in the schools of Dr. Maria Montessori (Fig. 13.5) are also based on a philosophy of education which recognizes the children's preference for control over their own learning. One has only to consider some of the various "discoveries"\(^1\) that she made about the learning modes of the children with whom she worked (Standing, 1962).

As you consider each of the Montessori discoveries that follow, consider how each might be borne out and amplified in the "prepared environment" of appropriate computer-based learning. Some of the discoveries may come as a surprise if you are not an experienced teacher. If they run counter to your own experience, either as a student or as a teacher in training, suspend disbelief and keep an open mind as you read along. Rest assured that these discoveries are re-discovered every day, not just in classrooms modeled after Montessori's ideas, but in classrooms in general all over the world. The goal of education is to make these discoveries habitual.

**Children have "amazing mental concentration" when their interest in anything is spontaneous** Hence the importance of the "prepared environment" designed to naturally capture a child's interest and stimulate the desire to learn. This interest and desire to learn will be fostered in the classroom in which the children have access to a range of computer-based learning systems alongside other more traditional learning tools.

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\(^1\) "Discoveries" is in quotes because, of course, Dr. Montessori was by no means the first to recognize these realities of children in relation to learning. Nor was she the last. They did, however, take her by surprise; thus for her they were discoveries, as they may be for you, too. Teachers everyday make these same discoveries working with individual children or with groups. They rejoice when they do because it means that the children have become responsible for their own learning, thus taking the awesome burden for that off the teachers' shoulders.
Chapter 13: Reflections on Education for an Information Age

Children "love repetition of material even when it is already known" Montessori describes this as a "profound psychological need" during the early years of a child's education. The appropriately programmed computer can be an invaluable vehicle for such repetitive activity because, unlike teachers, it never gets tired. One has only to watch children playing video games to know how easily and exhaustively children are motivated by engaging computer-based activities. When these activities have the added value of being educationally constructive it seems sensible to take advantage of the computer's motivational capabilities.

Children love freedom of choice when it comes to activities This is why Montessori went to such pains to understand and define the appropriate "prepared environment" for her students depending on the developmental stage that they were at. The classroom was set up with carefully constructed learning aids (called "didactic materials") of all kinds. The children were left free to decide what they wanted to work at or, for that matter, they could decide to do nothing at all. Of course, Montessori recognized that one is only free when one has options, otherwise one has no choice; hence the considerable variety of stimulating learning materials that she prescribed for her classrooms.

It is beyond the scope of this book to detail all the "didactic materials" used in the Montessori classroom. The reader is referred to any of the many excellent texts on learning theory for a more extensive description of the Montessori Method. Standing (1962) would be a good place to start. Rita Kramer’s “Maria Montessori: A Biography,” (Putnam Books, 1976) is another excellent, honest appraisal of Montessori’s place in the history of education.

The didactic materials can be purchased from school suppliers or you can, of course, construct them yourself. With the computer in mind, didactic materials in the form of the growing selection of learning software would become part of the "prepared environment" in which the child could freely choose among the set of available activities.

Children prefer work to play The distinction between work and play is an artificial one. Culture to a large extent determines what we will perceive as either one or the other. For example, Winston Churchill liked to lay brick walls as a form of relaxation. If we create and maintain a learning environment where the children can enjoy what they are doing—which includes the option to do nothing—they will be more likely to busy themselves with useful activities. As one teacher observed: "Kids who have fun will work harder." Even Plato, that advocate of mental discipline as the basis for learning (Bigge, 1982), commented that "early education [should] be a sort of amusement; [for] you will then be better able to find out the natural bent."

Naturally, when work is perceived as play it will be preferred over activities that are perceived as less enjoyable. Teachers who have the opportunity to work with small groups of, let us say, ten or fewer students know how much easier it is to maintain a pleasant, flexible, and child-oriented learning environment. One of the problems in most classrooms is that the teacher-pupil ratio is still so high that it is next to impossible to provide an environment where the children can be allowed to "do what they want." So teachers
perpetuate the methodology they themselves endured through their years of schooling, a methodology that depends largely on the principle of regimentation.

The computerized classroom can go a long way to overcoming the problem of numbers. Classes can be more easily broken up into small groups, or individuals can be left to work on their own. The teacher becomes the facilitator of learning rather than the source of it.

**Children love silence** When we are trying to think, we usually find noise a distraction. Children will be the first to appreciate the opportunity to work undisturbed. This is why teachers place so much emphasis on discipline in class; not to stifle intellectual activity, but to maintain an environment in which it can flourish. Classrooms in which the children have access to computer-based learning systems, while still needing adult supervision, will often not need much of it because the children are engaged.

**Children "explode into writing" once they have learned the letters of the alphabet and the sounds they represent** Children do not need to be taught to write. The *Writing To Read* program developed by Dr. John Henry Martin and sponsored by IBM would seem to contradict this approach. But in fact, as this discovery bears out, there is no contradiction. The Montessori children first learn the letters and the sounds they represent; this leads naturally to the discovery of an ability to construct written words. It is only several months later do they learn to read those written words.

**Children are spontaneously self-disciplined**—and extremely obedient—in a Montessori environment. The reason is simple: the children are engaged in activities of their own choice which absorb their attention to the extent of obviating much of the need for externally applied discipline. Standing (1962) calls it a "cosmic discipline." He quotes Montessori herself as saying: "The quiet in the class when the children were at work was complete and moving. No one had enforced it; and what is more, no one could have obtained it by external means." Teachers who have had experience working with children in well-planned, well-designed computer-based learning environments can corroborate this "discovery" for themselves.

Software that has been carefully crafted and selected by trained and experienced educationists for the purpose of stimulating learning in children will, in the hands of those children—at their own pace and in their own time—achieve the same effect as a teacher for many learning situations. There are, moreover, significant advantages to the computer-based learning stimulus:

- The child can have 100% of the computer's attention.
- The computer frees up the teacher for important interaction with other children who may need more help.
- The computer-based learning system gives the child complete control over the pace of learning. This echoes the aspiration of the philosopher George Bernard Shaw who said: "What we want is to see the child in pursuit of knowledge, not knowledge in pursuit of the child."
- In the long run computer-based learning will realize significant economies as the cost of teachers continues to rise while the cost of computing falls.
The Computer Is an Invaluable Tool for Classroom Management

We already discussed this aspect of computing in chapter 5. There we noted the value of the computer as a tool to assist in developing useful templates for letters, forms, ditto masters, and so forth. We also saw that the computer is a major time saver when it comes to specifying curricula, preparing syllabi, planning lessons, and preparing learning materials of all kinds.

Test preparation and evaluation also can be assisted by the computer. More and more text books come with test generation software which takes much of the drudgery out of preparing tests.

The computer is useful as a visual aid in its own right. Soft copy materials can be prepared on the computer and then projected directly onto a large screen. Student assessment and guidance is supported by controlled access to a database of student information, which more and more schools maintain.

Finally, communication with parents is facilitated by online tools such as those described in chapters 7 and 8 and which help with attendance management, dissemination of notices of all kinds (including what assignments the children have been set), and various other pedagogical outcomes that are best handled by interaction with parents (Bauch, 1990).

The Computer Is the Best Writing Implement Yet Invented

The research profiled in chapter 1 overwhelmingly concluded that the word processor and the tools associated with it had a significant effect on the quality of student writing. This is bound to spill over into other areas of the curriculum since writing is fundamental to the acquisition, reinforcement, and assimilation of knowledge in all fields.

At a conference on Writing Across the Curriculum offered at Pennsylvania State University in 1987, the keynote address, given by Dr. James R. Squire, was entitled 'Writing to Learn.' The message was simple: the act of writing, of organizing ideas with a view to communicating to others, does more than simply demonstrate what knowledge we have. It reinforces, transforms, and activates that knowledge.

Writing is a powerful, often painstaking process the execution of which is perhaps the most educational cognitive activity in which we, and our students, can be engaged. And it is a process appropriate to all subjects right across the curriculum.

Word Processing to Learn If it is true that writing contributes significantly to the assimilation of knowledge, and if it is true that the computer is the most versatile writing implement yet invented, then it follows that efforts should be expended at all levels of education to make the facility of computerized word processing available to all students. The beauty of this goal is that it is based on the simple, but powerful, concept—that of "Writing to Learn."

As Mageau (1992) reflected in an editorial to Electronic Learning: "For the rest of the world for whom writing is a painful and difficult process, being given a revision tool like a word processor is like being given the key to your jail cell." Mageau goes on to point out that the word processor does not magically turn a poor writer into a good one. Only people can do that.

The word processor removes one barrier to the process—the physical difficulty of revision. "What ultimately helps non-writers to write—and rewrite," says Mageau, "is a good teacher who enables
students to see that their voice, their ideas, and their ways of thinking are worth exploring and sharing with others."

CAVEATS REGARDING COMPUTER USE IN THE CLASSROOM

Computers Should Not Be Used For Purely Passive Learning

Computer learning should invite interaction. This interaction can take many forms, amongst which might be the following:

- Responding to questions.
- Finding answers to questions.
- Writing.
- Doing math.
- Preparing and giving presentations.
- Communicating and collaborating with classmates and others.
- Reacting to, and interacting with, simulations.
- Browsing databases such as the World Wide Web containing text, video, and audio material—always, with young children, under the careful guidance of the well-prepared teacher.
- Accessing and processing information for inclusion in other research products.

A Computer Does Not Take the Craft Out of Writing

At several points in this text we have considered the beneficial effects of word processing on writing. There is a danger, however, of too much emphasis being put on the appearance of students' work, rather than on the content. Hill (1992) quotes Hilary Cowan, instructional technology program director for Kanawha County Schools in West Virginia, who observed: "It's important that the process in process writing isn't skipped. I think it's too easy on a word processor to go from step one to the final finished product with little thought in between."

A carpenter must still understand the nature of wood, and have the knowledge and skills to produce good work, even though he or she will make use of powerful tools to expedite the work.

Spelling Checkers Do Not Have All the Answers

Spelling checkers are very useful for picking up misspelled or mis-typed words. However, they are no good for misused homonyms (too, to, two) and, of course, they cannot account for ignorance (as, for example, when a student takes something for “granite” when it should be taken for “granted”).

The dictionary that accompanies a spelling checker cannot contain every word under the sun. Students have to be told that if a word is flagged as not appearing in the dictionary, this does not mean the word has been misspelled. It simply may not be in the dictionary.

Many spelling checkers will offer suggestions of alternative words for those it cannot find in the online dictionary. This can be hazardous to some students' academic health! Sometimes a student
will substitute an incorrect word just because it has been suggested by the spelling checker. For example, a student who was writing a story about “Samson and Delilah” wrote instead about “Salmon and Delilah.” As it happens, proper names are usually omitted from online dictionaries, and sure enough the first alternative suggestion made by the spelling checker for the unknown Samson was Salmon!

Computers Cannot Replace the Teacher's Skill and Experience

As already emphasized throughout this text, computers do not replace teachers. They are tools that teachers use to directly or indirectly work more effectively with children. Teachers use the computer directly by selecting programs that will address individual and group learning needs based on experience. Teachers use the computer indirectly by taking on new roles in the classroom as computer-based learning takes over some of the traditional teaching tasks.

CAI can add significantly to the quality of the learning experience, and a skilled teacher will capitalize on the help that technology provides by investing his or her own efforts in a higher level of individual or group-specific attention. But the computer will not replace the teacher any time soon.

Computers Should Not Be Allowed to Take Away From the Teacher's Responsibility for Careful Class Preparation

The fact that teaching tasks such as preparation (of audio-visual aids, tests, worksheets, and so forth) is simplified should not take away from the teacher's responsibility to plan with the same care, whether or not the computer is used.

For example, computerized test banks make test generation a snap, but teachers still need to consider the design of the tests they prepare. Tests that include only short essay responses may handicap those students who are not good at explaining what they know in the sometimes frantic time constraints of an in-class test. If the objective of short essay tests is to determine whether the student can write, then it is a different matter, though it is debatable whether a timed test is an appropriate method to assess writing ability.

Another problem with test generators is the quality or otherwise of the questions that are provided in the database. Are the questions unambiguous? Do the questions adequately test the material that is the subject-matter? Have the questions been chosen and/or phrased in such a way as to not favor one group or another on the basis of race, gender, or ethnic background? If the answer set is generated by the software, are the answers to the questions correct? This is especially relevant for single correct answer questions such as matching, multiple choice, fill in the blanks, or true/false.

When the questions are supplied along with the software that accompanies a text, a teacher must verify the accuracy and appropriateness of every question included in a test. There is no guarantee that each time a topic is covered the same emphasis is given to different components of the topic, so questions may well need to be revised from semester to semester, even from class to class.

As it happens, the computer makes it easier to update tests. Thus, customizing tests for different learning situations should be the rule rather than the exception. In the same way, computer-based tools should make it easier for teachers to keep all their teaching materials current. Computers,
therefore, should be seen as providing an opportunity for seeking excellence, rather than as an opportunity to short-circuit it.

**The Computer Can Be an Excellent Child Minder, but that is Not How It Should be Used**

This is often a question of perception. Assuming that the software available for use in schools is selected on the basis of its educational value, it is possible to argue that any time the students spend using it they are in a learning mode. But it may not be an appropriate learning mode. So the teacher must plan for productive student use of the technology. In other words, students should not be let loose on the machines with the primary purpose of pacifying them.

Learning theory is the foundation for teaching. It goes without saying that the incorporation of the computer into the curriculum should in no sense take away from the teacher's commitment to creating and managing an environment in which learning is most likely. Fancy schmancy software that carries the "educational" label may not be effective in achieving its stated "educational" goals—even if the children love using it.

Pacification is not learning. Even when a computer-based system has proved effective elsewhere, with other children in other learning environments, it does not abrogate the teacher's responsibility to monitor the impact of that same system on a particular class of students with a view to assessing learning outcomes.

By the same token, a teacher who incorporates a computer-based learning system into the curriculum has the responsibility to validate that system in the context of the learning theory that is the intellectual foundation of teaching. Software evaluation, which we considered in chapter 6, is thus an important skill. The process of evaluation presupposes familiarity with the various theories that have arisen from the study of learning.

**Computers Should Not Be Used Purely as Electronic Page Turners**

This is a common complaint of teachers who are unenthusiastic about computer-based learning. The complaint usually stems either from ignorance or from previous unfortunate experience of poorly designed CAI. Certainly, this complaint is justified if the computer is used for no other purpose than to work linearly, page by page, through some passive study of textual material.

But this is rarely the case with CAI, especially that which involves multidimensional access to varied types of data—text, images, video, sound—as in multimedia systems. Nor is it the case when the study involves the accessing of text in a non-linear fashion, as in textual database research where the student moves from one text to another following an associational path linked by key words.

Can you think of other ways in which computers should not be used in education?

**COMPUTER-INTEGRATED TEACHING AND LEARNING: THE TEN Pillars of SUCCESS**

What, then, are some of the prerequisites to successful implementation of a technology program? In chapter 1 we briefly looked at the Ten Pillars of Successful Technology Integration. It is time
to examine this set of pre-requisites in more detail. Table 13.1 lists them and following the table is a discussion of each Pillar.

### The Ten Pillars of Successful Technology Integration

1. Leadership must provide active and committed support
2. Selling is better than telling—everyone needs to buy in to the change that technology brings
3. Invest in, and train, a core of teacher-technologists
4. Recognize that technological change is fast—keeping up-to-date is challenging and essential
5. All teachers must receive on-going training
6. All teachers must receive technical support—ideally on-site and on demand
7. Use it or lose it—teachers must plan on integrating technologies in order to maintain currency and fluency in its application
8. Parents and students must be actively involved in the evolutionary process
9. There must be planned and systematic financial investment in technology-integrated teaching and learning
10. Recognize that technology is for all, and that it involves all in the process of lifelong learning

Table 13.1 The Ten Pillars of Success

Let us examine each of these pillars of success one by one.

**Pillar 1: Leadership provides active and committed support--financial, logistical, and moral**

A technology program is only going to succeed when school boards, school superintendents, and school principals commit to it in word and deed. As already noted, a well-developed grant proposal will include written commitments of support from those who hold the local reins of power. This support would take the form of practical allocations in terms of all necessary release time and training for those teachers and administrators who are responsible for implementing a grant.

Lumley (1992) quotes teachers as saying: "If we don't receive active leadership and support from our principal and superintendent, technology just doesn't happen!" Lumley then goes on to itemize the characteristics of leadership required of effective superintendents and principals: these leaders have to be planners, visionaries, supporters, facilitators, and decision-makers.

This author has been involved in IT training for teachers in a school district where the superintendent attended every single one of the 14 three-hour-long classes AND insisted that all his principals did the same! Now that’s leadership! The superintendent walked the walk, and it made all the difference.
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**Pillar 2: Selling is better than telling**

The best leadership establishes an environment in which expected outcomes occur spontaneously. Technology should never be forced on teachers; its use should never come as a mandate from on high. Teachers, unfortunately, are no different than other professionals when it comes to sabotaging systems that they do not like and do not want.

So teachers must be given the opportunity to prepare for the kind of change that computer technology brings. This is a major challenge, and one that has been sadly neglected in too many school districts during the first decade and a half of computer use in schools. Considering how carelessly computer systems have been introduced, it is hardly surprising that some teachers have resisted accommodating them in their curriculum.

The best leadership therefore enables teachers to become the best that they can be through consultation, collaboration, communication, support, respect, and encouragement. The best leadership must also work to supply and maintain an "appropriate environment" that will function as fertile ground for educationally sound outcomes.

Teachers are only one variable in a complex educational equation. Just as students need teachers to help them establish a "prepared environment" for learning, so teachers need an administration that will be committed to helping them help the students. As the principal at a school founded by Maggie Cromer expresses it so well: "Schools are institutions where people of good will work together for the children."

**Pillar 3: Invest in and train a core team of teacher-computerists**

A teacher-computerist is a person who is committed to using computer-based educational technology and who has been given the opportunity to gain a sufficiently high level of expertise to qualify them to act as role models, advisors, and trouble shooters in matters to do with computer-based educational technology. In every school there should be one or more teacher-computerists, the number depending on the size of the school and, of course, on the school's commitment to educational computing.

Teacher-computerists should be given adequate release time to fulfill the following roles and tasks:

- to work with other teachers, as individuals or in groups, introducing them to new systems, arranging product demonstrations and helping them with any technical or pedagogical problems that may arise;
- to work with administration, planning near and long range computing strategies and mediating on behalf of teachers to help ensure that their needs are addressed;
- to work with vendors (suppliers of hardware and software), organizing product demonstrations, making sure that products are delivered as ordered and that warranties are negotiated and fulfilled.

Teachers are the ideal people to work with other teachers because they understand their needs. Teachers who are also computerists will be further suited to help their colleagues learn about computers because they are trained as teachers, and have experience working with computing
novices. They are therefore less likely to frighten off other teachers who may be timid about getting into the technology.

**Pillar 4: Recognize that technological change is fast and that keeping up to date is challenging and essential**

Preparation that involves computer technology puts greater demands on the teacher in terms of time than more traditional methodologies. Typically, teachers K-12 have far too little time to prepare and follow-up on classes. It is all very well to say that they have those long summers off when they could be planning new lessons, learning new methodologies and incorporating them into their curricula. Many teachers already do this. But long-range (what is also called "remote") preparation can only accomplish so much. Immediate preparation, designing classes to meet the needs of today's students today, must be done in the context of the live situation once the semester is underway.

Thus, it is tempting for teachers to take the easy route, teaching as they were taught, teaching the old-fashioned way, with barely more than chalk and talk by way of a methodology. School districts must therefore provide teachers with every opportunity to stay abreast of advances in technology and, more importantly, must give the teachers time to integrate teaching and learning technologies into the curriculum.

**Pillar 5: All teachers receive on-going training**

Too many schools put computers in the hands of the students and then magically expect the teachers to take advantage of the situation in their teaching. As Elmer-Dewitt (1991) observed, teachers should be the first to receive hardware and software systems and should be the first to be trained to use it. The teachers are the leaders in the classroom. How can they take advantage of the first of these secrets of successful integration of technology into their curricula (Active support must come from the top) unless they have sufficient knowledge and skill to feel that they are in control?

As long ago as 1989, the Shoreline Public Schools gave a computer to each of its approximately 600 teachers (Schlumpf, 1991). The school district began this "Apple for the Teacher" program because it believed in "giving teachers direct access to their own computer [as] the most logical step towards facilitating the professional development and maintaining the excellence of [their] staff. Teachers were to feel free to take the computers home if they so wished, and to that end carrying cases were provided, too.

At schools such as the Lausanne Collegiate School in Memphis, Tennessee, Lorrie Jackson organizes half-hour “Tuesday Techtorials” to which all teachers are invited and which provide hands-on training throughout the school year.

**Pillar 6: All teachers receive on-going technical support**

Technical support should be on site and on demand. To quote Debbie Drewien, Instructional Technology Specialist for the Blaine County School District in Idaho, USA: “I whole-heartedly support [the] view that being on-site where you can respond to teachers’ needs Just-In-Time and build those relationships with them so that they are willing to invite you in is so important. They
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will rarely call you if you are [squirreled away somewhere] at the district office. Out of “site”, out of mind (if you’ll pardon the pun)!

Sometimes an adversarial relationship can develop between the technology support team and the teachers because the tech support team may be understaffed and overwhelmed with problems that arise on a daily basis. Also, tech support may not understand teachers’ needs because they may not themselves be trained teachers. But Jeff Hogan, Instructional Technology Resource Teacher at the Blankner School in Orlando, Florida, USA puts it well when he says: “In the best possible world (which is the one I live in because I choose to make it the best) instructional technology (IT) is faculty and staff. We are a team and we do it all for the students.”

Pillar 7: Use it or lose it

On-going training is important for two reasons. First, computer technology is notorious for the pace of change that has accompanied its development. Second, anxiety generally accompanies this change. The technology is advancing so rapidly that faculty skills quickly become obsolete as new hardware and/or software systems are introduced. Commitment to a technology-based teaching and learning program will wane unless the teachers are routinely helped with the process of learning new skills.

Practice makes perfect, as they say. Lack of practice can easily lead to the loss of previously acquired skills.

Anxiety is a human factor which can have both good and bad effects. The best kind of anxiety, such as that experienced by a teacher working with new material or with a new class—or with new technology, for that matter—improves preparation, raises concentration levels, and gives the spark of life to the new experience. This good anxiety is welcomed by good teachers because they know it is productive for all concerned.

But anxiety can also be counter-productive, causing retreat from progress into the secure shell of the humdrum. This bad anxiety is often triggered by the careless introduction of innovative methodologies. Bracey (1988) cites the research of Honeyman and Warren of Lehigh and Kansas State universities respectively which showed that teachers needed on average a minimum of 30 contact hours with computers before they felt they had overcome initial anxiety about using them. Bracey (1988) went on to note the findings of Wedman and Heller at the University of Northern Iowa that teachers need to overcome their anxiety around computers first, without regard for how the technology might be applied in teaching and learning. An added level of anxiety can easily accompany using the technology in an actual classroom full of students who might quite possibly know more about computers than the teacher does.

Bracey concluded that technological innovation takes time and that training programs should take into account the negative potential for anxiety induced by unreasonable expectations. Capper (1988) corroborates this conclusion and emphasizes that even experienced teachers who are new to computer technology should be given ample opportunity to feel at ease using the equipment before requiring them to prepare specifically for the incorporation of the computer into their curriculum.
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**Pillar 8: Parents and students are actively involved in the evolutionary process**

There should be continuity between home and school. This applies to all aspects of education. Parents should feel that their child's classroom is *their* classroom, too. Today, in the United States at least, more and more parents have an online computer for their child in the home. But even where this is not the case, parents should at least be provided with feedback on the existence and effectiveness of a technology program in the child’s classroom. Schools—administration and faculty—have to appreciate the value of getting parents directly or indirectly involved in the classroom.

Most parents are passive in this regard, especially after the first year or two of a child's formal education. The best schools appreciate the power of parental involvement and thus actively foster close relationships between parents and the school for students of all ages—even at the college level. Most schools have PTAs, many have parent-teacher days/evenings, some structure routine home visits by teachers, and in at least a few schools the principal accompanies teachers when they visit the home of one of their students.

Computer technology is now being used routinely to promote contact and communication between the school and the home. As was discussed in chapter 7, parents and teachers can maintain close contact on a daily basis via computer/telephone system hookups (Bauch, 1991). There are schools that not only put a computer on every teacher's desk, but they also install a phone and a modem alongside that computer which allows parents and students to interact with teachers over electronic and voice mail systems.

Information has been defined as "a reduction in uncertainty" (Shannon & Weaver, 1949). Effective communication enabled by computer-based technology can help remove much of the uncertainty that surrounds many parents' perceptions of the education their children are getting in school.

**Pillar 9: There must be planned and systematic financial investment in technology-integrated teaching and learning**

In times of economic adversity, school districts should resist the temptation to trim the educational technology budget. Modern computer-based instructional technologies rapidly become obsolete, so a commitment to funding technology-integrated teaching and learning is a necessity, not an option. This commitment has to be seen as long term, with careful planning to ensure that money is well-spent.

**Pillar 10: Technology is for all and involves all in the process of lifelong learning**

Children today are growing up with modern computer-based technology as part and parcel of their lives. They are digital natives; they cannot imagine their lives without access to technology. Learning at school and at home can be seamless and integrated when the technology is made available in both environments. Parents, children, teachers and administrators will all work towards enabling learning as something which children do not “switch off” when they leave the classroom, but rather relish whenever opportunity allows.
By way of a summary of all of the above, listen to the words of a School District Technology Coordinator, Jeff Johnson of the Greendale School District in Wisconsin, USA, who has many years of experience on both sides of the technology fence—as a technology-using classroom teacher and as a professional devoted to helping teachers make the best use of technology in their classrooms.

“The importance of planning cannot be overstated. When teachers or departments find some hardware or software that they feel would positively impact their curriculum and improve student achievement, there should be a process in place where several individuals/committees review the request. The teacher or department making the request should be able to document and demonstrate the educational value of the purchase. But that's not the only factor in considering whether or not the purchase should be made.

“Frustrations with the IT staff often come from the IT staff’s lack of understanding of teachers’ needs and the view that The Network is the reason we all work in schools. I’ve been in this situation myself; it is very frustrating, as a teacher, to try to work with the IT director to help him or her understand why things need to be done in a different way.

“On the other hand, district/school leaders needs to understand that demonstrating the educational value of the latest new hardware or software isn't the whole picture -- someone still has to install and support it. It is not unusual for a school district to add more technology in the classrooms and labs, thus raising the level of expectations for teachers and students, while actually reducing the number of people directly associated with tech support.

“Where this is the case, there has to be a plan in place to improve teacher technology competencies along with a plan for managing technology. In other words, teachers should be expected to have some basic level of knowledge when it comes to using (and troubleshooting) technology. Support costs, too, need to be figured into the overall value of adding new technologies in schools. If the support piece is missing, it will be very frustrating for everyone, teachers and IT staff alike.

This amounts to changing the way things are done in many school districts and, as we all know, change is hard. There are plenty of educators that resist change. Leadership is important here, as well as the understanding that change takes time.”

In summary, then, leadership in schools could do worse than apply the secrets of success outlined above for establishing a prepared environment in which methodologies involving computer-based teaching and learning will flourish. Provide active support for technology-using teachers; take a non-dictatorial approach; make sure that every school has a core of teacher-computerists; ensure all necessary technical support; put the teachers’ needs first; get the parents and students involved; ensure that an on-going technology training program is in place; and last, but not least, give the teachers time and freedom to restructure their curriculum around the technology.
TAKING CARE OF THE TEACHERS

It is important to recognize that realistically it is difficult for teachers to embrace this technology with any success unless they have time, ongoing training, and logistical and technical support. Let us briefly reflect on these prerequisites of successful integration of technology in the classroom.

**Teachers Must Have Time**

One of the long-standing anomalies of education systems worldwide has been that teachers in elementary and secondary schools spend much more time in class than teachers in post-secondary schools. Teachers in schools K-12 typically spend well over twice as many contact hours in class than their collegiate counterparts.

Why the discrepancy? Is it because K-12 teachers need less time to prepare their lessons? No. Is there less need for K-12 teachers to keep abreast of current knowledge in their field of academic interest? No. Do K-12 teachers expend less energy in the classroom? Of course not! But the anomaly persists.

*A Nation at Risk* merits careful reading, identifying as it does various problems with the American K-12 educational system and making specific recommendations to ameliorate those problems. The report recognizes "the dedication, against all odds, that keeps teachers serving in schools and colleges, even as the rewards diminish."

However, nowhere in the report was it suggested as part of a solution to these problems that teacher-pupil ratios should be reduced or that K-12 teachers should be allocated fewer contact hours a week. For every hour that a teacher teaches, he or she probably needs to commit three or four hours of pre- or post-class time for purposes of preparation, evaluation, and follow-up. But the reality is that elementary and secondary school teachers do not get adequate time for immediate preparation for class. They do not get adequate time for student assessment, performance evaluation, and follow-up. They do not get adequate time to establish and maintain crucial communication with the children's homes. And we have not begun to address the need for adequate time to update teaching methods in line with the latest developments in educational technology.

*A Nation at Risk* did note that "not enough of the academically able students are being attracted to teaching," and that "the professional working life of teachers is on the whole unacceptable." The report also recommended, among other things, that teachers should have "an 11-month contract" so as to "ensure time for curriculum and professional development ... and a more adequate level of teacher compensation." But extending the contract and raising the compensation does nothing to fundamentally change the way the schools are organized as far as the teachers are concerned. In fact, the burden on teachers might actually be increased if the report's recommendations for a longer school day (7 hours) and a longer school year (200 to 220 days) were implemented unless, at the same time, schools reduced teacher-pupil ratios and teaching loads.

Unfortunately, many teachers become disillusioned after a few years in a system that works against their best efforts to serve the students. According to Perelman (1990): "One teacher I
interviewed could have spoken for thousands when she said: "Why should I do anything different next year from what I did last year? Who cares?"

Are the ideas for reducing teacher-pupil ratios and contact hours practicable? Would the quality of education in our elementary and secondary schools improve if reforms such as these were implemented? Can computer technology come to the rescue by enabling a radical restructuring of the whole process of childhood education? Might the time indeed come, as discussed in chapters 7 and 8, when a fair proportion of a student's interaction with a teacher will be electronic ("videotronic") in a distance learning mode?

**Teachers Must Have Ongoing Training**

The need for ongoing training in educational technology is not met by a one day workshop once a semester. Ongoing training means at least a weekly structured session of, say, two to three hours during release time from what would otherwise be teaching responsibilities. This structured time would be spent working through online or video tutorials, or working one-on-one with the school's technology support staff, or working with similar age group and subject area teachers planning, designing and evaluating technology-integrated lessons. This would give teachers at least an even chance of making the transition to teaching with technology without compromising the quality of their day-to-day work with students.

The alternative is for things to remain the way they are, with some 80% of teachers doing no more than pay lip service to the call to update their teaching methods. This includes teachers who began the transition process by attending courses and workshops in the past, but whose enthusiasm has petered out once they realized how much ongoing effort was involved.

The components of training sessions should include the following:

- evaluating new software;
- giving or receiving training in newly acquired hardware or software;
- discussing with colleagues methodologies for incorporating new software into the curriculum;
- attending or giving district-wide workshops;
- attending or giving model lessons.

**Teachers Must Have Logistical and Technical Support**

Logistical support begets the need for technical support. Once schools commit to computer-based education, there is a logistical price to pay in terms of hardware, software, service contracts and computer supplies. Pillar (1992) and others have reported on the waste that follows when there is inadequate logistical and technical support for educational computing systems. Teachers should not expect to have to support and maintain computer systems. They already have too little time to learn how to use the computer and how to incorporate it into the curriculum.

The majority of teachers love to teach. They have worked hard to develop skills and methodologies which have proven successful. They recognize the value of computers in the classroom. The majority of teachers welcome the opportunity to integrate the computer into the curriculum and have the instincts and experience to put the technology to its best use. But
unfortunately the majority of teachers do not yet have a technology-rich classroom even if they wanted one. Nor do the majority of teachers get the time and funding to support their regular attendance at training seminars and conferences.

This is a situation which has to be remedied before schools can ever hope to adequately address the educational needs of students in an information age.

A FINAL WORD

The Great American educationist, John Dewey, should have the last word in this book. He was born before the American Civil War and lived to see the beginnings of the computer revolution. His perspective on education described here was first published in 1900, but it has a relevance now more than ever before, since the "media necessary to further the growth of the child" are being extended beyond most educators’ wildest dreams.
"The occupations and relationships of the home environment are not specially selected for the growth of the child; the main object is something else, and what the child can get out of them is incidental. Hence the need of a school. In this school the life of the child becomes the all-controlling aim. All the media necessary to further the growth of the child center there. Learning? certainly, but living primarily, and learning through and in relation to this living. When we take the life of the child [that has been] centered and organized in this way, we do not find that he is first of all a listening being; quite the contrary.

"The statement so frequently made that education means "drawing out" is excellent, if we mean simply to contrast it with the process of pouring in. But, after all, it is difficult to connect the idea of drawing out with the ordinary doings of the child of three, four, seven, or eight years of age. He is already running over, spilling over, with activities of all kinds. He is not a purely latent being whom the adult has to approach with great caution and skill in order gradually to draw out some hidden germ of activity. The child is already intensely active, and the question of education is the question of taking hold of his activities, of giving them direction. Through direction, through organized use, they tend toward valuable results, instead of scattering or being left to merely impulsive expression.

"If we keep this before us, the difficulty I find uppermost in the minds of many people regarding what is termed the new education is not so much solved as dissolved; it disappears. A question often asked is: If you begin with the child's ideas, impulses, and interests, all so crude, so random and scattering, so little refined or spiritualized, how is he going to get the necessary discipline, culture, and information? If there were no way open to us except to excite and indulge these impulses of the child, the question might well be asked. We should either have to ignore and repress the activities or else to humor them. But if we have organization of equipment and materials, there is another path open to us. We can direct the child's activities, giving them exercise along certain lines, and can thus lead up to the goal which logically stands at the end of the paths followed." (emphasis added)

**LOOKING BACK**

There is not likely to be a revolution in education. Instead there will be a steady evolution that will involve integration of the new along with the tried and true. In this chapter we have reviewed traditional learning theories and methodologies in order to show that computer-based learning will be most effective if founded on principles and practices that have proved themselves over centuries of experience teaching children.

We have looked at ways in which the computer should and should not be used in the classroom. In all human achievement quality is characterized by careful preparation, conscientious implementation, and continuous evaluation, revision and reaffirmation of goals. The same must apply to the incorporation of computers into the curriculum.

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1 John Dewey’s book, *The Child and the Curriculum and The School and the Life of the Child*, was first published in 1900. The edition from which this quotation has been taken was published by Phoenix Books, University of Chicago Press, 1956.
We also reflected on the goals for education as set by the future workplace, in order to show how these goals can be effectively reached by schools which take advantage of technology in preparing students to take their place in the working world. Technology can help teachers to individualize education in a way that has been elusive up till now. When classes are large, it is difficult for even the best-willed teacher to attend adequately to individual student needs. But carefully integrated computer-based learning environments can both enable the teacher to provide individualized learning experiences and free up the teacher to work one-on-one with students.

LOOKING FORWARD

We have come to the end our journey in this book, which is where your journey in the computerized classroom of the Information Age begins. The fundamental content of this book has focused on practical matters related to computer use in teaching and learning. While there are many important philosophical and pedagogical issues that relate to the management of computer-based learning, there are also many skills that must first be learned—and then practiced so that the skills are not lost. Here is what the famous French tennis player, Jean Borotra, has to say about practice: "Never give it up, my friend. You must play a little every day." Likewise with technology. Use it or lose it, as they say.

You must keep your computing skills well-honed by attending workshops, conferences and seminars. The technology is charging ahead and is difficult to keep up with. If you are, or hope to be, in a school district where computer-based learning is supported by the community, take advantage of the opportunity to add to your skills and apply them in the classroom. Resolve to provide for your students the best-possible learning environment. As Eleanor Doan put it so well: “Good tools do not make a good teacher; but a good teacher makes good use of tools.”