

# Parents' Guide to Computers in Education

Dave Moursund

Access this book at: <http://uoregon.edu/~moursund/Books/Parents/Parents-Guide.html>

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"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change." (Charles Darwin)

"Mankind owes to the child the best it has to give." (United Nations Declaration of the Rights of the Child, 1959)

## Brief Summary

This short book is for parents who want their preschool and school age children to get a good, modern education. While the main focus is on Information and Communication Technology (ICT) aspects of education, many other educational topics are briefly covered.

Parents and other caregivers play a huge role in the informal and formal education of their children. Working alone and in cooperation with teachers, you (a parent, grandparent, etc.) can help your children get a much better education than they will receive without your explicit help.

This is especially true in the area of computers and other ICT. The average child spends more hours per week playing and working with multimedia (games, television, music players, cell phones, and so on) than in school. This situation presents you and your children with a major opportunity to improve their informal and formal education.

In addition, our school systems have been slow to integrate ICT into the everyday curriculum. The school-based education of many children is weak because it does not help students to take advantage of the capabilities of ICT as an aid to solving complex problems and accomplishing complex tasks. You, working with your children and their schools, can help to change this situation.

In brief summary, you can help your children to get a better education than they are currently getting. This will give them a competitive advantage throughout their lives!

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## About Dave Moursund, the Author

"Before you become too entranced with gorgeous gadgets and mesmerizing video displays, let me remind you that information is not knowledge, knowledge is not wisdom, and wisdom is not foresight. Each grows out of the other, and we need them all." (Arthur C. Clark)

"The wisest mind has something yet to learn." George Santayana)

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- Associate Professor, Department of Mathematics and Computing Center, University of Oregon.
- Associate and then Full Professor, Department of Computer Science, University of Oregon.
- Served six years as the first Head of the Computer Science Department at the University of Oregon.
- Full Professor in the College of Education at the UO for more than 20 years.
- In 1974, started the publication that eventually *became Learning and Leading with Technology*, the flagship publication of the International Society for Technology in Education (ISTE).
- In 1979, founded the International Society for Technology in Education ). Headed this organization for 19 years.
- Author or co-author of about 40 books and several hundred articles in the field of computers in education.
- Presented about 200 workshops on various topics in the field of computers in education.
- Served as a major professor for about 50 doctoral students (six in math, the rest in education). Served on the doctoral committees of about 25 other students.
- For more information about Dave Moursund and for free online, no cost access to 20 of his books and a number of articles, go to <http://darkwing.uoregon.edu/~moursund/dave/>.

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# Part 1: Your Child's Safety is Job #1

Information and communication technology (ICT) provides all of us with new opportunities and threats. This book is for parents who want to help improve the quality of education that their children are receiving. The overall focus is on helping your children gain appropriate ICT knowledge and skills so they can take advantage of the opportunities that ICT provides.

However, ICT poses many threats—especially to children. Parents, our communities, and our schools can work together to minimize these threats.

Part 1 of this book consists of the preface and first chapter. The preface provides a quick overview of the book. Chapter 1 summarizes some key ideas about the threats and opportunities inherent to ICT.

## Preface and Brief Overview

"Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime." (Chinese proverb)

"Fortune favors the prepared mind." (Louis Pasteur)

Education systems in the United States and throughout the world are designed to prepare students for responsible and productive adulthood. Some students get much better educations than other students. A better education can give a person a competitive advantage at work, at home, at play, and as a responsible and productive adult.

In the United States and in most educational systems throughout the world, we are not doing nearly as well as we could and should at preparing students for the current and future highly computerized world. I view this as a sad situation—our educational systems are not adequately preparing students for responsible and productive adulthood in an Information Age world.

ICT includes computers, but it also includes the full range of tools and toys such as cell telephones, digital still and video cameras, digital music and video storage and playback devices, video games, computer-assisted instruction, the Internet and the Web, calculators and other handheld computing devices, GPS, and so on. As you know, ICT is changing at a rapid pace. It is clear that this high pace of change will continue far into the future.

### Our Educational System is Slow to Change

As you know, school systems are slow to change. Most schools are quite conservative. The teachers teach the way they were taught. New ideas based on changes in technology and educational research are slow to be incorporated into the classroom. For the most part, this does not disturb teachers or parents. Most tend to think about schools in terms of, "It was good enough for me, and it is good enough for my children."

One brief example shows how wrong that thinking is. The elementary and secondary schools you attended probably had a library of perhaps 5,000 to 10,000 books. Many were terribly out of

date. The teaching was mainly based on a small number of carefully selected textbooks, with new adoptions occurring on a six-year cycle.

The World Wide Web did not exist when you were a child. Now, it is by far the world's largest library and it continues to grow quite rapidly. Its current contents are equivalent to hundreds of millions of books. It is unlike any library that existed in "the good old days." It is an interactive, multimedia library, making use of audio and video as well as text.

In addition to this, the library provides access to many computer programs that can solve problems and accomplish tasks for you. That is, the library is not static. It provides powerful interactive aids to solving problems and accomplishing tasks.

The library also contains a wide variety of aids to learning. Interactive computer-assisted instruction and distance learning materials are available on a wide range of topics. Children need to be learning to learn in such environments, both for immediate use and because they are powerful aids to lifelong learning.

It is true that students in our schools are gaining some knowledge about the Web and some modest skills in using the Web in the academic areas they are studying. However, for the most part this instruction about and using the Web is designed to preserve the type of education you received as a child. It is not being used to substantially change and improve our overall educational system.

Students are not learning to learn in an interactive hypermedia environment. For example, reading and writing in an interactive non-linear multimedia environment is far different than reading and writing in a linear text-based environment. Students are not learning to take increasing responsibility for their own learning. They are not learning to become lifelong learners, whose education will continue at a high pace throughout their lives.

## About This Book

The goal of this book is to help you to help your children get a better education—one that better prepares them for life in our rapidly changing Information Age society. This book contains a number of explicit suggestions that may be applicable to your child or children.

This book is divided into five main sections.

**Part 1** includes the preface you are now reading and a chapter discussing threats and opportunities. Regardless of anything else you do in terms of the ICT education of your children, you should help to protect your children from major dangers inherent to ICT. If you aren't worried, you probably should be. The following is quoted from an August 9, 2006 issue of Yahoo News:

But the study found that aggressive solicitations—the ones involving requests for contact by mail, by phone or in person—remained steady compared with a similar study five years earlier. And the report found growth in online harassment and unwanted exposure to pornography.

The report defines solicitation broadly as any request to engage in sexual activities or sexual talk or give personal sexual information—as long as it was unwanted or came from an adult. Not all requests were deemed by the youth as distressing.

In the latest study of online youths ages 10 to 17, conducted from March to June 2005 as MySpace began its rapid ascent, 13 percent of respondents reported a sexual solicitation, compared with 19 percent in a 1999-2000 survey. In both studies, about 4 percent reported aggressive solicitations.

**Part 2** provides general background for all readers. There is a tremendous amount of accumulated research and practitioner knowledge about how to educate children. Indeed, there is so much accumulated knowledge that it overwhelms our educational system. The system tries to be all things to all people and has difficulty individualizing to individual children. As a parent, you can provide individual educational help and guidance to your children. This can make a huge difference in the quality of education that your children receive.

**Part 3** covers Brain and Mind Science, a field that is making many contributions to the research and practice in education. Researchers now have tools and techniques to peer inside a person's mind as the person learns and makes use of learning. This new research builds upon many decades of good work by educational researchers.

**Part 4** contains a miscellaneous variety of topics. Some may be of particular interest to you, and others may not. Pick and choose—these topics can be read in any order.

**The remainder of the book** contains a set of references, an appendix on good (free) sources of information relevant to the topics of the book, and an index. Most of the references are to Web-based materials, and provide a good starting point for further exploration of the topics. All of the information sources mentioned in the appendix are available on the Web.

Each chapter begins with one or more quotations. To see my collection of quotations, go to <http://darkwing.uoregon.edu/~moursund/dave/quotations.htm>.

## Chapter 1: Threats and Opportunities

“The illiterate of the 21st century will not be the one who can not read and write, but the one who can not learn, unlearn, and relearn.” (Alvin Toffler)

"The mind is not a vessel to be filled but a fire to be kindled."  
(Plutarch)

Computer technology is a powerful change agent. It provides possible advantages to many people and nations. However, it provides possible disadvantages and threats to other people and nations.

Much of the content of this book focuses on opportunities, and what you, our schools, and our local communities can do to help children gain an education that helps prepare them to benefit from these opportunities.

This first chapter focuses on the opposite extreme. It looks specifically at some of the threats that accompany ICT and its rapid proliferation throughout the world. As a parent, one of your prime concerns is the safety and well being of your children. This is also a prime concern of schools and government.

### Parent Opinions

As I talked with parents and others about the possible content of this book, two general themes arose:

1. Help parents and children learn about the dangers inherent to the Internet and other aspects of ICT. What are the threats, and what can one do to deal with these threats? Make sure they learn about viruses and spam.
2. Help parents guide their children in becoming competent and responsibly users of ICT. What are the opportunities, and what can one do to take advantage of these opportunities? How can parents help their children's schools to provide their children with an up to date education that appropriately reflect the rapidly increasing availability and uses of ICT.

While the majority of the book focuses on the second topic, this first chapter addresses the dangers and threats. The following quote may help to increase your awareness of online connectivity threats (Olsen, 2006):

According to a new study from research firm Harris Interactive, **roughly a third of parents said they don't feel confident about teaching kids how to use the Internet safely and responsibly.** Nevertheless, as many as 94 percent of parents have turned to Web content filters, monitoring software or advice from an adult friend to help shield their kids from harm on the Net

...

Kids are in the spotlight because they're spending more and more time online—at home, in schools and at the homes of friends. According to CIC, high school kids spend as much as 5.1 hours a day online when they're out of school, middle school children spend 4.9 hours daily and elementary school children spend 3.8 hours a day. **Experts say kids can be particularly**

**vulnerable to predators when divulging personal information on blogs, social networks or to marketers.** [Boldface added for emphasis.]

Such online threats are real, and they receive a lot of media coverage. Here is another example:

The Federal Trade Commission (FTC) has imposed a \$1 million fine on social networking site Xanga for violations of the 1998 Child Online Protection Act (COPA). The FTC contended that Xanga allowed users whose self-reported birthdays indicated they were less than 13 years old to create accounts. COPA forbids any company from collecting personal information from users under the age of 13 without parental notification and consent. Xanga reportedly had allowed 1.7 million users to register with birthdays indicating they were under 13. Although Xanga CEO John Hiler suggested that many of those 1.7 million birthdays might be from users older than 13 who used birthdays of pets, or example, the company said it would implement changes geared toward child safety. Previously, the largest fine imposed under COPA was \$400,000. In that case, UMG Recordings was fined for similarly collecting personal information from users under 13. CNET, 8 September 2006 [http://news.com.com/2100-1030\\_3-6113626.html](http://news.com.com/2100-1030_3-6113626.html).

Correction added 3/8/07. The article contains an error. It should be referring to the Children's Online Privacy Protection Act (COPPA).

U.S. News and World report contains an excellent article about MySpace (Andrews, 2006). Quoting from a Web-accessible copy of this article:

It's the coolest hangout space for teens-but parents might be surprised at what their kids do there. Here's how to help keep them safe online.

...

Among the many millions of people visiting these sites, some, indeed, are sexual predators, and there have been some highly publicized accounts of teenagers who've been lured into offline meetings at which they've been assaulted. Parents, understandably, are traumatized by such stories. By focusing so intently on protecting their kids from stalkers, however, parents have overlooked other less sensational but important aspects of their kids' online experiences. How teens interact with their peers in cyberspace, for example, and how they present themselves through images and words may not be life-or-death decisions, but they can have a serious impact on their lives offline. As the new school year begins, parents have an opportunity to take an interest and get involved in their kids' online experiences, if they haven't done so already.

### **To Learn or not to Learn: The Threats of an Inadequate Education**

You need to be aware, however, that there are other very serious threats that receive much less media attention. ICT provides general-purpose aids to problem solving and communication. In that regard, ICT is somewhat similar to reading, writing, arithmetic, speaking, and listening. That is, ICT can be thought of as a powerful extension to the basics that schools have stressed for hundreds of years.

Today's children face the threat that they will receive a totally inadequate ICT education. Sure, they will learn some ICT on their own.

Here is a snide question that you can ignore if you like. How many of today's adults learned to program a VCR on their own? The point to the question is that many people find it difficult to learn complex aspects of ICT on their own.

However, ICT is a broad and deep field, affecting every discipline students are currently studying in school. Most students are getting only a superficial understanding of roles of ICT in representing and solving the types of problems they study in school. They are not learning how

ICT is drastically changing the jobs of the future and the worldwide competition for gainful employment.

You should not be misled by your children's ability to learn to play computer games, to do instant messaging on a cell phone or computer, to download music, and so on. It is wonderful that children easily learn such ICT from each other. However, such ICT knowledge and skills are a far cry from those needed to routinely and confidently use ICT to help solve the types of problems and accomplish the types of tasks that are the core focus in our educational system.

You understand that there are many different subject areas, such as reading, writing, math, science, and social science. Starting more than 50 years ago, a new subject began to come into our colleges and universities. It was called computer science, or computer and information science. By the early 1960s, this subject made its way into high schools and by the 1970s, it was common to find some instruction in the computer programming languages BASIC or Logo in elementary schools.

Computer programming is only part of the field of computer and information science, but it is a central and unifying part. Nowadays, most children never get an opportunity to learn anything about computer programming. Their knowledge of computer science comes almost entirely from learning how to make use of a variety of computer tools and toys. They are missing out on learning the fundamentals of computer and information science. They are not able to bring an understanding of computational thinking to the subjects they study in school. Quoting from Jeannette Wing (2006), a highly respected computer scientist:

**Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine.** Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone.

...

**Computational thinking is a fundamental skill for everybody,** not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. [Bold added for emphasis.]

## The Threats of Entertainment

A later chapter of this book addresses some beneficial roles of games in education. Here, I address some of the threats.

It wasn't too many years ago that it was standard to find newspaper and magazine articles discussing how much time children were spending watching television. On average, children were spending more time per year watching television than they were in attending school.

Television is attention grabbing and attention holding. Many of our children and many of us find it easy to "veg" in front of a television set, letting the passive entertainment flow in.

Electronic games can be thought of as an extension of television. Think of interactive television in which you, the viewer, play an active role. You may be interacting with characters generated by the game and with characters that are being run by people from throughout the world. There may be a simple plot line, or there may be a complex plot line that continues over a long period of time. The latter situation is much like the soaps and other long running TV series.

The computer games get better year after year, as huge amounts of money are spent on developing games that are increasingly attention grabbing and attention holding. The steadily

increasing computer power makes it possible to develop games that are more realistic and interactive.

Even before computers, many people were addicted to various games, such as solitaire card games and poker. Now, we have games that are far more addictive. What is happening for many children is a shift from watching TV to playing electronic games. The electronic games are more “fun” than TV. The total time children spend watching TV and playing electronic games has increased as a result. On average, it significantly exceed time spent in school.

During this rather passive entertainment time, children are not developing the kinds of social skills that come from direct interaction with other children and adults. They are not physically active like they would be in running and chasing, and playing sports. They are not mentally engaged in the way that child are who are reading and interacting with other aspects of the non-gaming world.

My message to you, a parent, is simple. You should severely restrict the amount of time your children spend watching television and playing electronic games. There are other important things in life besides being entertained by TV and such games.

### **Advergaming**

Probably you are familiar with television programs called infomercials that are essentially just long ads. Quoting from the Wikipedia:

Infomercials are television commercials that run as long as a typical television program (roughly 28 minutes, 30 seconds). Infomercials, also known as paid programming (or teleshopping in Europe), are normally shown outside of peak hours, such as late at night or early in the morning. ... As in any other form of advertisement, the content is a commercial message designed to represent the viewpoints and to serve the interest of the sponsor. Infomercials are often made to closely resemble actual television programming, usually talk shows, with minimal acknowledgement that the program is actually an advertisement.

Now, people are developing electronic games that are infomercials. These *advergames* are designed to have all of the characteristics of pure entertainment games, such as being attention grabbing and attention holding. However, the games contain built-in advertising messages. The game may be designed to convince you that you want to join the army and “Be all that you can be.” The game may be designed to indoctrinate you into a particular way of thinking about or viewing the world. The game may be designed to sell specific products. In any case, this is a powerful and growing form of advertising.

### **Computer Viruses, Worms, Etc.**

There are a number of people who deliberately set out to destroy or damage the software and files on other people's computers and other computing devices. They develop computer programs that are specifically designed to cause damage. These programs go by a variety of names such as virus, worm, and Trojan horse. Quoting from the Wikipedia:

In computer security, a computer virus is a self-replicating computer program that spreads by inserting copies of itself into other executable code or documents. A computer virus behaves in a way similar to a biological virus, which spreads by inserting itself into living cells. Extending the analogy, the insertion of a virus into the program is termed as an "infection", and the infected file, or executable code that is not part of a file, is called a "host". Viruses are one of the several types of malicious software or malware. In common parlance, the term virus is often extended to refer to worms, Trojan horses and other sorts of malware; viruses in the narrow sense of the word are less common than they used to be, compared to other forms of malware.

There are many ways that malware can get into your computer or handheld computing device. For example, virus or other malware may be attached to an email message you receive. Open the attachment, and the malware enters your computer system. This email virus may locate your email address book and email itself to all of the people in your email address book. Such an email virus can quickly spread throughout the world.

Another common means is through software that a person shares with you or that you download from the Web. When a friend shares software with you, you have no good way of knowing if it contains malware. When you download “free” software from the Web, you may be downloading software that contains malware. Recently, the search engine Google has added features to try to determine if a Website contains malware. When a person using Google asks to download from a site that Google thinks may contain malware, Google provides a warning message.

Every user of computers and handheld computing devices that connect to the Internet should be making use of filtering software designed to help catch malware. Nowadays, the cost of such filtering software should be considered as an ordinary part of the cost of making use of the Internet. In addition, all Internet users (which includes all Web users) should be alert for obvious attacks against their computer systems. For example, when you receive email from some person or address that is not familiar to you, and the email contains attachments, there is a good possibility that this is an email virus. Delete the email—do not open the attachments.

### **Telecommuting, Out Sourcing, and Off Shoring**

ICT makes it possible for people to work from home. Many people who work from home consider this as a great opportunity.

However, an extension of the ideas of telecommuting allow people to serve customers who are located thousands of miles away—even in different countries. Thus, workers in India can provide technical help and make sales via computer and telephone connectivity to customers in the United States. Accountants in China can prepare income tax returns customers in the U.S. This practice is sometimes called *off shoring*.

Such inexpensive long distance communication fit nicely with good transportation systems. The combination provides opportunities for skilled workers in low wage countries or areas in a country to compete for higher wage jobs located elsewhere. The combination also can increase the profit of a company that makes effective use of lower wage employees. At the same time, these opportunities are threats to the jobs of higher wage employees.

In addition, the transportation and ICT system make it possible for physical goods to be manufactured in low wage parts of a country or the world, and sold to customers throughout the world. This is often called *out sourcing*. Customers gain an advantage of lower costs, but manufacturing workers in higher wage areas face the threat of losing their jobs.

In summary, improvements in ICT and transportation help to create worldwide competition for certain types of jobs. The chances are that the future will bring move of this type of competition throughout the world.

### **Electronic Spam**

Quoting from the Wikipedia page [http://en.wikipedia.org/wiki/Spam\\_%28electronic%29](http://en.wikipedia.org/wiki/Spam_%28electronic%29):

Spamming is the abuse of electronic messaging systems to send unsolicited, bulk messages. While the most widely recognized form of spam is e-mail spam, the term is applied to similar abuses in other media: instant messaging spam, Usenet newsgroup spam, Web search engine spam, spam in blogs, and mobile phone messaging spam.

Electronic spam is a threat to all people who make use of email and various other types of Internet-facilitated communication. The spam messages may contain viruses, attempt to sell you products and services you are not interested in, and expose you to pornographic language and materials. For more detail, see the Wikipedia discussion of malware at <http://en.wikipedia.org/wiki/Malware>.

Essentially every day I receive a bunch of email messages designed to sell me a wide variety of different products I am not interested in and have not requested information about. I receive my incoming mail through a service provided by the University of Oregon. In addition, I use software designed to check for various types of spam. Still, in a typical day I spend a few minutes separating out and deleting spam.

Many ads I don't want to see pop up as I browse various Websites while I am writing a scholarly book or article. In addition, the smallest typo when entering a Web address may take me to a site that I would rather not visit—and that I would prefer my grandchildren not visit!

There is an ongoing battle between developers of filtering software and people working to circumvent filtering software. The use of such filtering software has become common in schools and in many public libraries. Similarly, there is an ongoing battle between developers of anti virus software, and developers of software viruses. This situation has reached a stage that most people find it highly beneficial to have virus protection software on their computers.

### **Thieves and Predators**

Many people make use of the Internet and other ICT capabilities for predatorily, unethical, and illegal activities. Many different activities fall into these categories. Some receive much more attention than others. For example, it seems like it is becoming increasingly common for “thieves” to steal computer files containing personal information about a lot of people. This information can be quite useful in identity theft.

The scam email I receive frequently includes a bogus message from a bank or credit union telling me that my account is under attack or something has gone wrong with it, and I can correct the matter by providing them with various pieces of information. These are blatant attempts to gain information needed for identity theft. Surely you should learn to recognize such blatant attempts at thievery and teach your children about the.

The social networking Websites, chat rooms, and other two-way Internet-based communication systems have become a vehicle for predators. I assume that as a parent, you teach your children about dangers they might face in the community and going to and from places such as school. You teach them appropriate levels of caution about accepting rides from strangers, not admitting strangers into their homes, and so on. ICT forces you to carry this education further. You must educate your children about the types of predation that can occur through use of the Internet. For some more suggestions, see the work of Nancy Willard (2006).

### **ICT provides Children with “Bad” Opportunities**

ICT has opened a number of opportunities for children to unethical and illegal activities. For example, consider intellectual property rights that can be stored transported, and used

electronically. Piracy of music and video is now commonplace. Many children feel it is perfectly acceptable to share commercial software, music, and video with their friends. Parents play a significant role in helping their children what is ethically, morally, and legally correct.

ICT makes it much easier to plagiarize. This problem has reached a level so that software is now available that teachers can use to try to determine if a paper turned in by a student contains plagiarized content. A variation on this problem is that there are a number of companies that offer term papers for sale. Many students now buy complete papers from various Web-based sources, and turn them in as their own work.

Some students engage in spamming, harassing, and cyber bullying activities. Some students maliciously damage or destroy other's electronic files. Some get into teacher's school's files and change records, such as grades.

Many parents are unhappy if their young children access publications such as Playboy Magazine and Playgirl Magazine. From parent's point of view, this may be considered immoral activity. Nowadays, children can readily access pornographic Websites that are far worse. It is much easier to keep inappropriate hard magazines and books out of the hands of your children than to keep them from accessing similar or worse materials on the Web.

### **Acceptable Use Policies**

All schools that have computers and Internet access face the problems of ICT safety and the need for their students to have appropriate ICT behavior while in school. The three most used approaches are:

1. Use of filtering software and other approaches to keep students from accessing inappropriate Websites, chat rooms, social networking sites, and so on.
2. An acceptable use policy (AUP) that provides details of acceptable and inappropriate uses of ICT in school. Education of students, parents, and teachers in this policy is essential. Both students and teachers need to know how to handle situations when they inadvertently encounter inappropriate materials on the Web.
3. Careful monitoring of student ICT use in school.
4. Avoiding publication of information predators might use to identify and communicate with specific students.

### **The Literature Giving Arguments Against use of Computers in Schools**

There are a substantial number of well-written books and articles that point out dangers of use of computers in education. Over the years, I have read a great many of these resources, and I have a great deal of respect for many of the authors. The following Website contains some brief information about some of these resources:

Moursund, David (n.d.). *Arguments against use of computers in education*. Retrieved 9/13/06:  
[http://otec.uoregon.edu/arguments\\_against.htm](http://otec.uoregon.edu/arguments_against.htm).

As an example, you might want to look at the Website of the Alliance for Childhood (<http://www.allianceforchildhood.net/index.htm>). Quoting from their Website:

Computers are reshaping children's lives at home and at school, in profound and unexpected ways. Common sense suggests that we consider the potential harm, as well as the promised benefits, of this change.

The Alliance for Childhood and dozens of leading health, education and child development experts are challenging the increasing emphasis on computers in early childhood and elementary schools. Please visit the Projects/Computers section of this web site to learn more about the Alliance computer project and to read our report, Fool's Gold: A Critical Look at Computers in Childhood.

You will also want to read Children and Computers: A Call to Action, a position statement signed by dozens of experts in child development, education, health, and technology.

A common argument against use of computers in schools is that they are not being used effectively and the money could better be used for other purposes. An article by Justin Appel (2006) includes this argument as it discusses the growth in the number of schools providing one computer for each student. Quoting from the article:

According to figures provided by the Bellevue, Wash.-based Anywhere Anytime Learning Foundation, the number of North American students enrolled in one-to-one programs is growing annually at 15 percent and now totals more than 500,000.

But even as these numbers drive higher, critics say the true costs of a comprehensive laptop program—from training staff, to drafting new curriculum, to installing wireless networks in schools—are just now becoming apparent.

"As educational dollars have grown more scarce, those extra costs give pause to more people," noted Larry Cuban, professor emeritus of education at Stanford University.

## **Working With Your Children and Their Schools**

To the extent possible, you want to provide your children with a safe, secure home and community. Parents have faced this challenge for tens of thousands of years. The development of formal schools about 5,000 years ago added a new dimension to the problem—the need for schools to be safe places. ICT has added to the challenge, both in homes and throughout the community, including in schools.

Schools are meeting this challenge by careful supervision of students, use of filtering software, acceptable use policies, and education of both teachers and students. Many schools restrict the software available to students on the school computers, and only allow students to access Websites that are considered appropriate. For example, schools may prohibit use of their ICT facilities for accessing known Social Networking sites, pornographic sites, racial hatred sites, and so on.

Acceptable use policies usually include a strong stress on intellectual property rights—to not maliciously damage or steal software, music, videos, and other electronic documents. They also stress the need to not plagiarize the works of others, and to provide proper attributions when legally copying or using pieces of other's works.

Parents are well advised to develop an acceptable use policy for ICT use at home and other places outside of school. A child's home AUP should apply to the child in other homes and places he or she visits in the community. This requires that parents monitor their children's use of ICT and educate them in the rules.

Television, electronic games, and telephones (including cell telephones) all should be addressed in a home AUP. How many hours a day do you want your children to spend watching

television, playing electronic games, instant messaging via computer or telephone, and chatting via computer or telephone? Each of these activities has some addictive-like qualities. Many children retreat into these activities, cutting themselves off from other very important physical and mental developmental activities.

Without such a strong and well-enforced home ACU policy, students face the dilemma of school policies that are considerably different than home and community policies. Parents face the likelihood that their children will routinely engage in ICT behavior that may be risky, unethical, or illegal.

Another important thing that parents can do is to play an active role in communicating with their children about the roles of a good education in being prepared for the world they will face as adults. There will be increasing worldwide competition for jobs. There will be increasing demand for the services of people who can solve problems and accomplish challenging tasks that require good thinking skills, a good education, and use of ICT.

## Part 2: General Information for All Readers

"Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it." (Samuel Johnson)

"Life's Tragedy is that we get old too soon and wise too late." (Benjamin Franklin)

### Brief Summary of Part 2

The goal of this book is to help you to help your children get a good education. Part 2 provides general background information and lays a foundation for the remaining parts of the book.

Many years ago, when I was first becoming a teacher and a teacher of teachers, I made up a simplified summary of the goals of education. My simplified statement was, "The goals of education are to learn some facts and to learn to think using the facts."

This rather naïve overview of education has served me well for many years, but it does not help much when it comes to providing detailed recommendations for improving education, or how parents can help. Spend a minute or so thinking about how to expand the two goals to better fit your personal insights into education.

One of the things to think about is rote memory versus understanding of what one is learning. Computers are very good at rote memory. The Web is a library containing the equivalent of tens of millions of books. Far more information is added to or changed in this library every day than a human could memorize in a lifetime.

There is a large and steadily growing body of research that provides a basis for substantially improving our educational system. In addition, the past few decades have brought us huge changes in technology that affect teaching, learning, and making use of what one has learned.

We know that a high quality informal and formal education makes a huge contribution to a student's ability to deal with the challenging problems challenging tasks they will face as adults. This educational process begins a birth and is heavily dependent on a child's home environment.

For example, research tells us that children coming from homes where parents talk to and with them a lot and make use of a relatively rich vocabulary enter school with several times the oral vocabulary as children who are raised in a poor oral communication environment. This gain is further enhanced by parents who read to their children a lot and expose them to a rich world of experiences and ideas. The net result is that such "advantaged" children enter kindergarten or the first grade a full year or more academically ahead of children raised in cognitively poor environments.

Similar advantages accrue to children whose home situation provides them with extensive training and practice in a sport such as juggling, tennis, or golf.

The unifying theme of this book is helping students to get an education in which they learn to make effective use of their brains and computers to solve challenging problems and accomplish challenging tasks. The term *computational thinking* is used to describe what I mean. Here is a

brief quote from Jeannette Wing, head of the Computer Science Department at Carnegie Mellon University (Wing, 2006):

**Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine.** Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers, and What can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answer to such questions.

**Computational thinking is a fundamental skill for everybody,** not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. [Bold added for emphasis.]

There is an interesting parallel between the Industrial Age (machines to aid our muscle power) and our current Information Age (machines to aid our brains power). You are used to the idea of machines that aid your physical body, such as a plow, boat, bicycle, car, train, airplane, and rocket ship. The steam engine fueled the beginnings of the Industrial Age. We have come a long way since then. When I drive my car, I provide the goal and a variety of driving skills, while the car provides a hundred horsepower, wheels, seats, heating, air conditioning, and so on. My car and I work together to accomplish the task of moving me to where I want to go.

In recent years, however, cars have been getting smarter. A new car may contain a GPS (global positioning system) that provides you with oral directions and a map to take you where you want to go. The car may contain a computer-controlled crash avoidance system that provides warnings and can apply the breaks. Indeed, in a recent contest funded by the US government, several cars were able to complete a 131.6-mile journey across the Mojave Desert—without human drivers!

The point is, Information and Communication Technology (ICT) is bringing an increasing amount of intelligence or intelligent-like behavior to machines. A three-dollar solar battery-powered handheld calculator can likely do multi digit multiplication and long division more accurately and much faster than you can using pencil and paper. You and your calculator are a more powerful doer of arithmetic than you alone, unaided by a calculator.

Today's laptop or desktop computer is millions as times as fast as an inexpensive handheld calculator. ICT brings us powerful aids to solving problems and accomplishing tasks in every academic discipline. In every academic discipline, there are many tasks that a person plus computer can far out perform a person working alone. A modern education prepares students for adult life in such a world.

## Chapter 2: The Three R's and ICT

"The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom." (Isaac Asimov, *Isaac Asimov's Book of Science and Nature Quotations*, 1988)

Have you ever stopped to wonder why reading, writing, and arithmetic (the three R's) are considered the basics in education? The answer is simple enough. These are intellectual tools—aids to your brain—that do three basic things:

1. They allow for the storage, organization, movement, and retrieval of information. Thus, they make possible a steadily growing accumulation of information that can be preserved for years and shared among a large number of people.
2. They are an aid to the human brain. For example, reading and writing help to overcome a person's rote memory weaknesses. Reading and writing of math symbols makes it possible to learn to do math computations and manipulations that a typical person cannot do mentally.
3. They are an aid to learning and teaching.

The same three statements hold for computers! Information and Communication Technology (ICT) builds upon and in some sense can be considered as an extension of the three R's. This chapter provides a brief historical perspective of human-developed aids to mind and body.

### Agricultural Age

Historical records suggest that 11,000 years ago, the human population of earth was about 12 million—we now have a number of cities larger than that. People lived as hunter-gatherers in small groups. They made use of tools such as fire, spear, stone ax, and stone knife that had existed for tens of thousands of years.

During the hunter-gather era, there was very little technological change from one generation to the next. In many parts of the world, living conditions were harsh. Moreover, there were large parts of the world that were cut off from each other. Travel over long distances was very difficult. For all practical purposes, North and South America were cut off from the rest of the world.

About 11,000 to 12,000 years ago conditions became right for the development of agriculture in the Fertile Crescent, in the area we here in the United States now call the Middle East. People began to plant crops, raise farm animals, and build permanent settlements. Populations began to increase, from small tribes to villages to cities.

Over a period of many thousands of years, selective cultivation and breeding led to crops and animals that were better suited to the needs of farmers and animal herders. Forms of governments developed to fit the needs of cities and city-states. Trade routes developed and modes of transportation and organization were developed to move quantities of goods along these

trade routes. Modes of record keeping were developed to facilitate government, taxation, and commerce.

About 10,000 years ago, clay tokens began to play a key role in this record keeping system. A clay token shaped like an animal could be used to represent the animal. A government tax collector might give such a token to a farmer as a receipt for a goat taken as a tax. Eventually, clay envelopes, with clay tokens sealed inside and the quantity of such tokens marked on the outside, became a common aid to commerce.

Soon after 4,000 B.C., the clay tokens were combined with the idea of sealing [tokens in a clay envelop] to create bills of lading and warehouse receipts. To create a bill of lading for a consignment of sheep, the owner put in a one-sheep token for every sheep. Every time he counted five sheep, a five-sheep token could be substituted for a one-sheep token. Once the owner and the consignee agreed on the count, the tokens were placed in a wet clay envelope. The owner and the consignee rolled their seals over the envelope, then let it dry (Szabo, 2002).

A clay token is a picture representation of a word or phrase, such as *ampoule of grain* or *five sheep*. The clay token vocabulary grew very slowly. After about 5,000 years of use of clay tokens, the vocabulary was perhaps 200 different tokens. Such a small vocabulary eventually proved insufficient to meet the needs.

The Sumerians invented reading, writing, and a written number system about 5,200 years ago (Ancientscripts.com, n.d.). The country named Sumer was located in the Fertile Crescent, approximately where Iraq is located today. The three R's were the product of more than 5,000 years of Agricultural Age progress and change. Writing on clay tablets and other media replaced and extended the clay token system.

At first glance, the change from using clay tokens and clay envelopes may have seemed like a small thing. However, the development of a written language allowed for a far larger vocabulary and for a grammar that was not possible with clay tokens. This new technology also required a long period of study and practice to learn. It became necessary to have schools, formal schooling, and teachers skilled in teaching.

Thus, the Sumerians developed formal schools to teach the three R's. Initially a very small number of people went to school. The percentage of the population getting formal schooling, as well as the number of years of schooling, has increased substantially over the past 5,000 years.

The three R's can be thought of as tools designed to aid one's brain. Even a modest amount of formal education in the three R's makes a significant difference for a person. Thomas Jefferson, the third president of the United States, recognized this when he worked to have his home state of Virginia provide three years of free public grammar school education to those who could not afford to pay tuition. The three years of education would focus on reading, writing, and arithmetic. This was such a far-out idea, it was handily rejected by the Virginia legislature.

Now, less than 250 years later, we are greatly concerned about students who don't finish the 12<sup>th</sup> grade and graduate from high school. Public education is available at no cost, and law mandates many years of schooling. There continues to be a focus on students learning the three R's, but the standards have risen dramatically. A third grade education no longer suffices in today's complex and rapidly changing world.

## Industrial Age

The world has changed a lot since the invention of the three R's. Initially, the pace of change was slow. Most people saw very little change in agriculture, medicine, technology, science, mathematics, and education during their lifetimes. On average, these lifetimes were short compared to modern standards. Quoting from Life Expectancy n.d.):

Life expectancy before the 'health transition' of the modern era is thought to have varied between about 20 years and 35 years, depending upon particular circumstances. It has been suggested that life expectancy fell with the introduction of plant and animal domestication because of:

- higher infection rates caused by the increase in human settlement size and density,
- poorer nutrition due to reduced meat intake and a poorer vegetable diet.

The Agricultural Age lasted more than 10,000 years, until steam engines and other technology led to the start of the Industrial Age less than 250 years ago. In very simple terms, the industrial revolution was based on machines and tools that greatly helped to overcome human physical strength, stamina, and speed limitations.

It is estimated that the power of steam in Great Britain is equal to the labor of 170,000,000 men, in a population of only 28,000,000. (Scientific American, October, 1845,).

As a very rough estimate, this quotation suggests that those workers who were making use of steam-powered engines were having their physical power multiplied by a factor of 100. That is a huge change. Of course, nowadays many people think nothing of driving a car that has an engine a thousand times as powerful as a person.

Eventually the steam engine gave way to internal combustion engines and electric motors. Oil lamps gave way to electric lights. Horse and ox drawn plows and wagons gave way to powerful tractors and trucks fueled by petroleum products. Progress in the science and technology of electricity brought us the telegraph, telephone, radio, and then television. Many appliances such as refrigerators, air conditioners, washing machines, and vacuum cleaners have contributed to a substantial improvement of the average standard of living in industrialized parts of the world.

The Industrial Revolution, which began in England, provided the impetus for our current educational system. As farmers moved to the cities to work in factories, people became concerned about the farmers' children. Sure, six year olds could work in dangerous factories. However, eventually it was decided to develop schools and require children to go to school. Child labor laws were implemented. Many of the factory-like, mass production features of these early Industrial Age schools are still evident in today's schools.

## Information and Communication Technology

At the time of the Revolutionary War in the United States, 90-percent of employment was on farms. This changed, as the United States became an industrialized nation. A few years after the end of World War II, about 55-percent of the workforce in the United States held industrial manufacturing jobs.

During the past 50 years, the Industrial Age has given way to the Information Age. The number of Agricultural and Industrial jobs has continued to plummet. At the current time in the United States, very few people live as hunter-gathers, about two-percent of workers are farmers, and about 15 percent of workers are employed in industrial manufacturing (Industrial Age) jobs.

The huge majority of workers now have service jobs. There are a tremendous range of such jobs, including: clerks in small and large stores and eateries; teachers and other school personnel; doctors, nurses, and other medical personnel; government employees, including police and military; hotel and motel workers; and so on.

Information and Communication Technology has contributed to the transition from the Industrial Age to the Information Age. ICT is far more than just computers. The chances are that you use a cell telephone, and perhaps your cell telephone is also a digital still or video camera. You may own a car that contains dozens of built-in computers. Computer circuitry is an important component of radio, television, recording and playback devices, and so on. The Internet (which includes the Web) makes use of hundreds of thousands of computers and computer-based telecommunication systems. ICT has made major contributions to factory automation and to increased productivity of workers in many different occupations.

This book has a focus on ICT in informal and formal education. It would be nice to report how well ICT has done in increasing the productivity of teachers and students. However, such gains have not yet occurred. Throughout this book, I will help you to understand why this is the case, and what you can do about it for your own children and their schools.

### **Working With Your Children and Their Schools**

You have read this chapter, and it has raised some questions in your mind. You sense the pace of change in our world, from the time you were a child until now. You wonder what you can be doing to prepare your children for their adult lives as the pace of change continues to increase.

The single most important thing you can do is to role model the behaviors, values, and ways of being that you want your children to acquire, and to directly work to inculcate these into your children. For example, you know your children will need to be lifelong learners and continually adjusting to change. Do you role model being a lifelong learner who readily adjusts to change? Do you talk with your children about learning and the value of learning, and how this learning helps as the world changes? Do you take an active role in your children's informal and formal education, often learning alongside your children and learning from your children?

Since you are reading this book, it is clear that you have considerable insight into the value of having good understanding and skills in the three R's. How do you help your children develop such values? This chapter suggests that ICT has many of the characteristics of the three R's. Have you developed ICT knowledge and skills that blend with and augment your knowledge, skills, and understanding of the three R's? Have you ever carried on conversations with your children about this blending and augmentation?

Make up some similar questions that seem important to you. These might be about communication using cell phones, instant messaging, and the Internet. They might be about information retrieval from the Web, or online shopping. In each case, think about what you have learned and what you might want to learn. Think about what you want your children to learn and how you can facilitate this learning. In some cases, your children may already know more than you. Use such situations to learn from your children and to role model being a lifelong learner!

## Chapter 3: Goals of Education

"If you don't know where you are going, you're likely to end up somewhere else." (Lawrence J. Peter, of "Peter's Principles" fame.

All successful people have a goal. No one can get anywhere unless he knows where he wants to go." (Norman Vincent Peale)

Each person has their own ideas about suitable general goals for our informal and formal education system. In addition, people have varying opinions on goals within specific academic disciplines such as language arts, math, science, and social science.

Unlike most countries, the United States does not have a national educational system and national curriculum. Thus, goals for education vary somewhat from state to state. However, under the *No Child Left Behind* act of 2001, the U.S. has implemented a number of requirements on schools and school districts throughout the country (NCLB, n.d.).

In terms of ICT in education, most states have established standards based on the National Educational Technology Standards developed by the International Society for Technology in Education (ISTE NETS, n.d.). [Author's note: I founded ISTE in 1979 and ran this non-profit professional society for 19 years.]

### General Goals of Education

Here is a short list of widely accepted general goals of education:

1. **Acquisition and retention of basic, important, knowledge and skills.** There is considerable agreement that reading, writing, arithmetic, speaking, listening, information retrieval, and use of retrieved information are basic and important for all students. Even then, however, there is disagreement about ways to achieve these goals in a cost effective manner that has a very high probability of success. There is even less agreement on what students should learn in the fine and performing arts, health, science, social science, physical education, and other commonly taught disciplines.
2. **Understanding of one's acquired knowledge and skills.** *Understanding* tends to be difficult to define and measure. However, there is considerable agreement nowadays that education must proceed far beyond rote memorization.
3. **Active use of one's acquired knowledge and skills.** This includes being able to transfer one's learning to new settings, and being able to analyze and solve novel problems. We expect our educational system to:
  - a. Provide challenging and rigorous programs of study designed to help each student become a literate, responsible, and creative adult citizen.
  - b. Help each student learn to learn, learn to take responsibility for their own learning, understand his or her capabilities and limitations as a

learner, and to develop intrinsic (internal, self) motivation, drive, and other lifelong habits of learning.

- c. Help each student learn to help others learn. In this, it is helpful to think of each student as a teacher. For example, students often help each other and their siblings to learn, and parents spend a lot of time in “teacher” mode.
- d. Help each student learn to cope with technological, social, and other forms of change that will be occurring during his or her lifetime.

Pay particular attention to the third goal and its specific objectives. We want students to learn to make use of their education to solve problems, accomplish tasks, and deal with novel situations. We want students to have an education that helps them to become responsible, productive adults. We want these adults to be lifelong learners who cope with change and who help others (including their children and grandchildren) to learn.

These general goals do not speak to values-based goals or goals such as preserving and passing on the culture of a family or community. You, as a parent, play a major role in the values and cultural education of your children.

### **Information and Communication Technology Goals**

I was the Executive officer of ISTE during the time it was developing the ISTE National Educational Technology Standards (NETS), and then made them available in June 1998.

Details on the 1998 NETS are available at ISTE NETS (n.d.). This Website includes profiles of what students are expected to be able to do at the end of grades 2, 5, 8, and 12. For example, quoting from the Website:

Prior to completion of Grade 5, students will:

1. Use keyboards and other common input and output devices (including adaptive devices when necessary) efficiently and effectively.
2. Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.
3. Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use.
4. Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.
5. Use technology tools (e.g., multimedia authoring, presentation, Web tools, digital cameras, scanners) for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.
6. Use telecommunications efficiently to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.
7. Use telecommunications and online resources (e.g., e-mail, online discussions, Web environments) to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.
8. Use technology resources (e.g., calculators, data collection probes, videos, educational software) for problem solving, self-directed learning, and extended learning activities.
9. Determine which technology is useful and select the appropriate tool(s) and technology resources to address a variety of tasks and problems.

10. Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources.

For most people, the Grade 5 list is an eye opener. Most states in the United States have adopted ICT standards somewhat similar to the ISTE NETS. However, relatively few schools have been successful in implementing these standards. The great majority of students completing high school do not meet these fifth grade standards.

It is not that these standards are too difficult to meet. They are being achieved in some schools. Rather, it is that the combined efforts of teachers, parents, and others to implement these standards have not been adequate to the task in most schools. Given appropriate instruction, facilities, and encouragement, average students can meet these standards.

Schools offer a number of reasons why students are not receiving an ICT education that meets the ISTE NETS. The three most common excuses are:

1. Inadequate facilities—not enough computers, poor connectivity, not enough of the right software.
2. Inadequate staff development.
3. Strong pressure to emphasize the language arts (reading and writing) and math components of state and national testing, due to the No Child Left Behind legislation.

The validity of these excuses varies tremendously from school to school. On average in the United States, schools have approximately one microcomputer per 3.5 students. Essentially all schools have Internet connectivity (and thus, email and Web access). There are a small but steadily growing number of classrooms, schools, and school districts that provide a computer for every student. This is called one-to-one computing (n.d.). Note that over three-fourths of students live in homes that have a computer. On average, the national level of home access to computers is considerably better than as school access.

A significant amount of staff development for ICT in education has been funded at federal, state, regional, and local levels for the past two to three decades. The past decade has also seen a huge influx of federal money into teacher education programs throughout the country. These funds have helped prepare many new teachers, following the guidelines provided by the ISTE National Educational Technology Standards for Teachers (ISTE NETS•T, 2000).

In spite of the huge amount of resources that have gone into ICT-related staff development, many teachers are indeed poorly prepared in this area. It takes a long time to learn ICT and how to teach in an ICT environment. Moreover, such preparation needs to be ongoing, because the field of ICT in education is continuing to change quite rapidly.

### **No Child Left Behind**

The federally mandated No Child Left Behind state and national testing requirements are strongly influencing curriculum throughout the country. Many teachers and schools are teaching to the tests. They are spending more and more time on the subjects that are tested and on how to take tests. This is taking time away from very important school subjects such as art, music, science, social science, and so on.

Moreover, this narrow testing focus does not support integration of ICT into the general curriculum. The first chapter of this book drew a parallel between the three R's and ICT. We

want students to learn to read. Reading interactive multimedia material on the Web is both somewhat like and quite different from reading a static, linear, printed book. Writing interactive multimedia material for Web publication is both somewhat like and quite different from writing a static *hard copy* document. Using a calculator or a computer to do math is both somewhat like and quite different from doing mental and paper & pencil math.

During the past 20 years, our state and national testing systems have come to accept that is all right for students to use a calculator on tests. In a growing number of situations, students are tested in an online environment, and thus are required to use computers while being assessed. However, we are a very long way from allowing students complete access to the general tools a compute can provide while they are taking state and national tests.

Thus, for example, many students are learning to write in a word processing environment, where they have ready access to a spelling checker, dictionary, and thesaurus. Seldom are they allowed to take tests in this environment.

### **Working With Your Children and Their Schools**

ICT includes a number of tools that are now routinely used in every discipline of study. Some of these tools are natural extensions of the traditional basics of education, such as reading, writing, and arithmetic. Adults who have developed fluency in their use are apt to routinely draw upon their ICT knowledge and skills on their jobs and other intellectual activities.

If you routinely use a computer as an aid to your reading, writing, arithmetic, and other academic skills, then you can help your children to learn to do similar things. This can begin at a very young age. For example, perhaps you use email at home, sending and receiving text messages, pictures, and video. Help your children to learn what you are doing, by role modeling and making it explicit what you are doing. "See, Pat. I am reading an email from grandma. See the nice pictures she sent. Now I am writing an email to grandma. Let's take a picture of you to send to grandma. You can take a picture of me to send her. ..."

Young children can learn to use a digital still camera. For them, it is a "neat toy" and they get immediate feedback by seeing the pictures that they have taken. Quite a few years ago, I visited a kindergarten in which the students used digital cameras. The lesson I viewed included a "field trip" in which the children explored the school and playgrounds and took pictures. The students were supervised by the teacher and a teacher's aide. The teacher then loaded the pictures into a computer. Each child talked about their own picture, why they took that particular picture, what they liked about their picture, and what might make it a better picture. It was a very nice activity.

It is easy to find out if your children are meeting the ISTE NETS for their grade range. Just read the profiles from the ISTE site and then carry on a conversation with your children about whether they are learning to do these things in school. If they say they are, and if you have a home computer, have them demonstrate to you. When you talk to your children about "what did you do in school today," ask about their use of computers and other ICT. When you have parent-teacher conference meetings, ask about what students are learning about computers. Ask for details and to see samples of the work your child has been doing using computers and other ICT.

Your school district may have a set of goals for ICT in education. If so, obtain a copy and talk to your children about the goals. You may well be able to help them meet some of the learning goals, and you may be able to peak their interests in learning some ICT.

## Chapter 4: The Internet

"An educated mind is, as it were, composed of all the minds of preceding ages." (Bernard Le Bovier Fontenelle, mathematical historian, 1657-1757)

"An individual understands a concept, skill, theory, or domain of knowledge to the extent that he or she can apply it appropriately in a new situation." (Howard Gardner)

The invention of reading and writing made it possible for humans to store and retrieve information in an entirely new way. The work of scholars could be accumulated and passed on to others without the use of face-to-face meetings between the scholars and the students.

The development of the electric telegraph, telephone, radio, and television changed the way people communicate. In some sense, these modes of one-way and two-way communication have made the world much "smaller." They have not replaced the need for reading and writing.

The Internet is a worldwide network of interconnected computer networks that transmit data. This network of networks consists of millions of smaller domestic, academic, business, and government networks, which together carry various information and services, such as electronic mail, online chat, and the Web. The Internet is significantly changing our world—and, it is making it still smaller.

### Some History

Many people measure distance in terms of time. Thus, in talking about where I live, I might say "eight minutes from work, an hour and 15 minutes from the coast, and an hour and a half from a ski resort. These are driving times under normal driving conditions.

Historically, distances have often been stated in terms of days of travel. The "distance" thus might vary depending on whether the travel was on foot, horseback, or ship. In those days, communication over significant distances moved at the pace of a person on foot, horseback, or on a ship.

The Industrial Revolution changed this. The steam engine made possible the steam locomotive and the steam ship. People and goods could be moved faster. The world (using time as a measure of distance) became smaller. As the Industrial Revolution continued, petroleum-powered automobiles and trucks were developed. Super highways were developed. Airplanes were developed and came into common use. The world became a lot smaller.

The development of the electronic telegraph, telephone, radio, television, email, and cell phone have all contributed to improving communication and making the world smaller from a communication point of view.

Industrial Age transportation has been combined with Information Age communication to make possible UPS, FedEx, and other delivery systems. The combination of Industrial Age ideas with Information Age ideas in factories have made possible a high level of individualization of mass-produced goods, as well as "just in time" manufacturing of many products. The way businesses interact with customers and deliver products has greatly changed in recent years.

## Libraries—Historically and Now

The Library of Alexandria—once the greatest library in the world— was a collection of scrolls. Most of these scrolls were made of papyrus, an early form of paper made from the pith of the papyrus plant. Quoting from <http://en.wikipedia.org/wiki/Library>:

In the traditional sense of the word, a **library** is a collection of books and periodicals. It can refer to an individual's private collection, but more often it is a large collection that is funded and maintained by a city or institution.

...

However, with the collection or invention of media other than books for storing information, many libraries are now also repositories and access points for maps, prints or other artwork, microfilm, microfiche, audio tapes, CDs, LPs, video tapes and DVDs, and provide public facilities to access CD-ROM and subscription databases and the Internet. Thus, modern libraries are increasingly being redefined as places to get unrestricted access to information in many formats and from many sources.

The chances are that you have a quite substantial personal library of hard copy and electronic information. All of your books, magazines, records, audio and video tapes, hard copy and digital still and video photographic materials, CDs, DVDs, and information stored in your computer, and other storages and playback devices are part of your personal library.

You have undoubtedly hear the expression, “A picture is worth a thousand words.” Actually, a four-mega pixel digital photograph contains more information than a thick novel! A DVD can contain the equivalent of more than a thousand novels. If one measures a personal library just in terms of the number of bits or bytes of information that is stored, your personal home library is probably much larger than the Library of Alexandria.

## The Web

However, your personal library pales to insignificance when compared to the Web. The Web is a virtual library, with its various components stored on hundreds of thousands of different computers scattered throughout the world. Quoting from [http://en.wikipedia.org/wiki/History\\_of\\_the\\_World\\_Wide\\_Web](http://en.wikipedia.org/wiki/History_of_the_World_Wide_Web):

The World Wide Web ("WWW" or simply the "Web") is a global information space which people can read and write via computers connected to the Internet. The term is often mistakenly used as a synonym for the Internet itself, but the Web is actually a service that operates over the Internet, just like e-mail.

The above-mentioned Website indicates that the early history of the Web dates back to work starting more than 25 years ago. While a variety of people made major contributions, Tim Berners-Lee is considered the father of the Web. On August 6, 1991, Berners-Lee posted a short summary of the World Wide Web project on the alt.hypertext newsgroup. This date also marked the debut of the Web as a publicly available service on the Internet.

Initially the Web was used mainly for communication among researchers. However, this changed quite rapidly. Now the Web is routinely used for commercial and non-commercial purposes by hundreds of millions of people throughout the world. Essentially every elementary and secondary school in the United States has Web access, and almost all students learn how to use the Web and make use of it in school.

The Web combines characteristics of a static, hard copy library with quite a bit of automation. When you use a search engine such as Google, you are making use of a powerful

component of library automation. Look at the website <http://www.google.com/intl/en/help/features.html#calculator>. There you will see how a Web-based tool can not only help you find information, it can also automatically carry out calculations to help solve various types of problems. There are a steadily growing number of Websites that can automatically solve problems for you.

In some sense, it is very easy to use the Web. If someone gives you a particular Web address, you key it in, wait for a little while, and then start reading. If you want to find information on a particular topic, you key a few words into a search engine, and likely the search engine comes up with many possible sources of the information. Certainly that is easier than using a card catalog.

On the other hand, it is rather difficult to use the Web. Even after you have found a suitable document to read, the chances are that it is a hypermedia document. That is, it is non-linear that may include text, sound, graphics, and video. Many people do not like to read off of a computer screen. Research suggests that it causes some people eyestrain, and that on average people get less comprehension when reading from a screen as compared to reading a hard copy document.

Second, there is the difficulty of reading a non-linear document that has many links, and then links within the documents linked to. How do you tell when you are done?

Third, a typical search using a search engine produces a large number of hits. The relevance and quality of these hits varies from good to terrible. Indeed, you may well get pornographic hits, racist hits, and so on. It is a significant challenge to learn to formulate a search so that the hits are likely to be what you want, and then to read in a manner that allows you to quickly separate the wheat from the chaff.

Here is one more problem that I frequently encounter. I try to find information in a relatively narrow area of research that I do not know well. I do not know the vocabulary used to describe the work and the results in that area. Often I am not able to find relevant results because I cannot formulate an appropriate search. I lack the domain-specific knowledge needed to retrieve and understand information in the domain.

Our school systems can be improved by providing students with significant instruction on how to use the Web. This instruction should be part of the teaching in each discipline.

## **The Open Source Movements**

The Web is a huge, virtual library. However, not all parts of this library are free. Many parts change people who want to use their contents. A similar situation exists for software.

This situation has led to the establishment of organizations that promote and help develop free content and free software. In both cases, people work individually or through organizations to develop content and software that is made available free. If you want to learn more about free software, search on *free software*. My recent Google search returned well over 2 billion hits. For example, see <http://www.fsf.org/licensing/essays/free-sw.html>.

I think my single most favorite source of free information is now the Wikipedia Encyclopedia. Quoting from <http://en.wikipedia.org/wiki/Wikipedia>:

The project began in January 2001, as a complement to the expert-written (and now defunct) Nupedia, and is now operated by the non-profit Wikimedia Foundation. It was created by Larry Sanger and Jimmy Wales; however, Sanger resigned from both Nupedia and Wikipedia on March 1, 2002.

Midway through 2006, Wikipedia had more than 4,600,000 articles in many languages, including more than 1,200,000 in the English-language version. There were more than 200 language editions of Wikipedia, fifteen of which had more than 50,000 articles each.

The Wikipedia articles have all been contributed. Most of the articles are set up so that any reader can contribute to or edit the article. A few are set up so that they cannot be changed by the readers. This has been necessary because of malicious changes being made in certain articles about political figures and other contentious topics.

This Web-library certainly contains a lot of text. Indeed, various projects have been going on for years have resulted in the digitization of hundreds of thousands of books. There are now many hundreds of free online periodicals. Quoting from The Directory of Open Access Journals (DOAJ, n.d.):

Welcome to the Directory of **Open Access Journals**. This service covers free, full text, quality controlled scientific and scholarly journals. We aim to cover all subjects and languages. There are now 2,314 journals in the directory. Currently 666 journals are searchable at article level. As of today 104,461 articles are included in the DOAJ service. [Bold added for emphasis.]

### **Working With Your Children and Their Schools**

Children are naturally curious. They often pose good, difficult, probing questions. A child's natural curiosity can be maintained and increased in a home and school environment that fosters and rewards curiosity. On the other hand, it can be beaten down and nearly destroyed by poor home and school environments.

A while ago, the National Educational Association was running an ad on television. In the ad, a child asks her father, "Daddy, why is the sky blue?" The father answers with an answer such as, "The sky is blue so that it will match your beautiful blue eyes." The ad then points out how this type of answer does not help a child's education.

Contrast the "blue eyes" answer with an answer that helps the child to learn about the atmosphere and light. You might want to spend some time on the Web to see how well you can do in finding a more educationally sound answer than that provided by the father.

More generally, when faced by the rather profound and challenging questions that children often pose, learn to respond with, "I am not sure I know. Let's work together on the Web to see if we can find some good answers." In education circles, this is called a "teachable moment."

## Chapter 5: Expertise in a Discipline

In short, learning is the process by which novices become experts. (John T. Bruer. *Schools for Thought*, 1999, page 13.)

An expert is a person who has made all the mistakes that can be made in a very narrow field. (Niels Bohr)

"All things are difficult before they are easy." (Thomas Fuller, 1654-1734)

In any discipline or field of study, a learner begins as a novice and then gradually increases in expertise. Increases in expertise come from concerted efforts over an extended period of time. It can take many years of study and practice to achieve one's potential in a discipline. The quality of the instruction—having good teachers, good coaches, lots of small group and one-on-one instruction—helps to determine how fast one gains in expertise and how high an expertise one attains.

It is fun to watch children grow and increase both in the breadth of their areas of interest and in their depths of expertise. In a child's early years of life, parents and other care givers make a high level of contribution to a child's breadth of areas of expertise and levels of expertise.

This chapter explores the general topic of expertise and roles of ICT in expertise.

### Islands of Expertise

I think the idea of *Islands of Expertise* is very interesting. The basic idea is that a person can select a small area and develop a relatively high level of expertise in that area. Building an island of expertise tends to boost a child's self esteem. It also provides a reference point for self-assessment) in future learning activities (Bruce, n.d.; Crowley and Jacobs, 2002).

An island of expertise is a personal accomplishment. The level of expertise can be viewed from a personal point of view—"I am better than this than I used to be, and I am proud of my accomplishments."

### What is a Discipline?

You know that students study a variety of different subjects in school. Elementary school, for example, spends much of its instructional time in just four disciplines—language arts (reading and writing), math, science, and social science. Some time is also spent in art, music, and various physical education activities. However, many other disciplines interest and involve children.

As a child, I went through a period of time when I collected Popsicle sticks and tinfoil (for example, from gum wrappers and cigarette packages). I was quite industrious at both of these endeavors, and so my collections were much larger than most of my peers. In some sense, I had two islands of expertise. Now, in retrospect, I am thinking about the extent to which one might think of the disciplines of collecting Popsicle sticks and tinfoil. I developed skill in knowing where to look. I developed some skill at peeling off tinfoil from paper in packaging, and rolling the tinfoil into a ball. I learned how to wash Popsicle sticks and make some really neat toys out of them.

However, I did not study about how Popsicle sticks are made, how many are made each year, and so on. I did not study about tin and how it is made into foil, its importance in packaging, or

why my parents were so careful about recycling their tin cans during World War 2. Thus, in retrospect, I learned only a modest amount about the overall “discipline” or area of study and accomplishment of Popsicle sticks and tinfoil.

Eventually I moved on to other areas. Some were equivalent to the two hobbies listed above. I collected matchbook covers, kite string, marbles, butterflies, and beach agates. In all cases, the goal was quantity. The learning that occurred within the various disciplines was rather limited and did not involve any direct study of available resources. Indeed, it never occurred to me that these were possible areas of study, and my parents did not suggest it.

Eventually I became interested in stamp collecting. I amassed a large collection of stamps, sorted them onto appropriate pages of an album, learned something about buying, selling, and trading stamps, learned some of the history of postage stamps, learned something about various countries that printed stamps, and so on. I learned about hyperinflation (although I did not learn this word) as I saw German postage stamps overprinted with larger and larger numbers. For me, my activities in the discipline of stamp collecting were more educationally useful than my activities in Popsicle sticks, tinfoil, kite string, and so on.

Each discipline of study and accomplishment has broad vistas. Each discipline can be defined by its unique combination of:

- The types of problems, tasks, and activities it addresses.
- Its tools, methodologies, and types of evidence and arguments used in solving problems, accomplishing tasks, and recording and sharing accumulated results.
- Its accumulated accomplishments such as results, achievements, products, performances, scope, power, uses, impact on the societies of the world, and so on.
- Its history, culture, unifying principles and standards of rigor, language (including notation and special vocabulary), and methods of teaching, learning, and assessment.
- Its particular sense of beauty and wonder. A mathematician’s idea of a “beautiful proof” is quite a bit different than an artist’s idea of a beautiful painting or a musician’s idea of a beautiful composition or performance.

This set of characteristics was mainly designed to satisfy faculty at the university where I work. Faculty members think of themselves as high-level experts in the disciplines they teach. They tend to be discipline-centric—that is, to view their discipline as being especially important relative to other disciplines.

## **Gaining Expertise**

There are thousands of different areas in which a person can develop some knowledge and skills. The pattern of this development tends to be the same regardless of the area.

A child is exposed to an area in which it is possible to demonstrate increasing levels of performance that are brought about through study and practice. The child begins as a novice, with a very low level of knowledge and skill. If the child’s interests and the supporting environment are conducive, the child gains in knowledge and skill. That is, the child gains an increasing level of expertise in the area. See Figure 4.1.

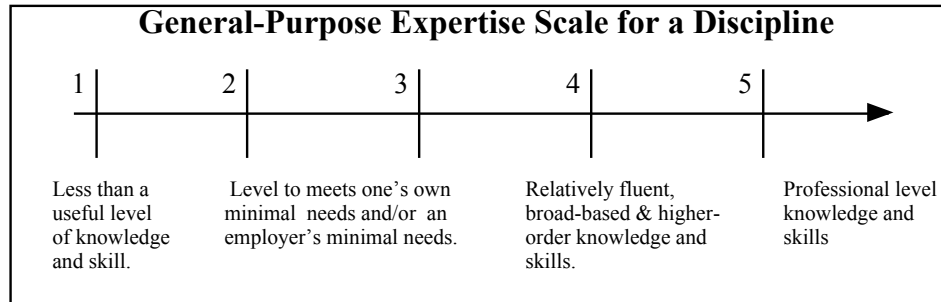


Figure 4.1. Expertise scale.

Children vary in how fast they gain increasing levels of expertise. Moreover, children vary in their upper limits. Not every child can become a world-class athlete, musician, artist, or scholar. Remember, however, there are many thousands of areas in which a child can be gaining an increasing level of expertise. By focused attention in one particular area that most people have little knowledge of, a child easily can become better than average compared to his or her peers. For example, I remember a student who I went to school with. This student learned tap dancing and performed in a school assembly. It could well be that this student was the best tap dancer in the school—perhaps because there were very few tap dancers in the school.

The subject of expertise has been explored by many researchers. Suppose a child is just beginning to learn a particular area such as playing the game of chess. Consider this child after 1 hour, 10 hours, 100 hours, 1,000 hours, and 10,000 hours of study and practice.

Progress can be quite rapid in the first hour. After an hour, the child knows the names of the pieces and often makes legal moves. After ten hours, the child plays the game. After a hundred hours, the child is likely a far better player than average, when compared to his or her peer group. After a thousand hours, a child may well be the best chess player at his or her grade level in the school or school district. After 10,000 hours, the child is getting close to achieving his or her full potential. If the child's combination of natural talent, internal motivation, family support, good teachers and coaches, tournament experience, and so on are appropriate, the child may well be world class in his or her age group.

Researchers tend to agree that 10,000 hours of study and practice is somewhat of a magical number. With that amount of study and practice, spread out over a number of years, a person begins to achieve their full potential in a particular discipline. It can take much longer. The average age of the current top ten chess players in the world is about 30. They have probably put in 20,000 to 30,000 hours to achieve their current levels of expertise. A similar statement holds for most world-class pianists, violinists, and tenured professors at good universities.

### **Roles of ICT in Gaining Expertise**

ICT plays two clear roles in many different areas of expertise. First, it provides access to relevant information and people who may have a similar area of interest. Second, knowledge and skills in ICT may be a significant component of the area.

I'll use a personal example to illustrate this. Writing educational books is one of my areas of expertise.

I can keyboard faster than I can write using a pen or pencil. Composing at a computer keyboard helps me in two important ways. First, the results are readable. Most people consider

my handwriting illegible. Second, it is far easier to edit text electronically than in a hard copy environment. Third, having my writings available in electronic form makes it much easier to use bits and pieces of my previous works in my new works.

I make use of a word processor that has a spelling checker, a grammar checker, a dictionary, and a thesaurus. I make frequent use of these aids to writing. I am connected to the Web and email as I write, and I make frequent use of these components of ICT to obtain ideas and information.

I write in a non-linear fashion, developing an outline as I proceed, and jumping around from topic to topic as I explore ideas. Many of the documents I write are books, and so I make use of the index feature, table of contents feature, and desktop publication features of my word processor. My writings often contain tables and lists, and so I make use of the built-in word processor features to help in this endeavor.

In summary, my computer and I work together to write. My computer contributes a great deal to this endeavor, but I supply the creativity and deep thinking that is required.

### **Working With Your Children and Their Schools**

Parents play a major role in young children developing islands of expertise. Observe your child's interests. Foster an interest and help it grow into an island of expertise. Examine your own islands of expertise. Help your child develop an interest in some of these areas.

Help your child understand the concepts of expertise, increasing expertise, and developing islands of expertise. These concepts can play a major role as you carry on conversations with your child about, "What did you do in school today?" Each day at school should help a child to gain an increasing level of expertise in a variety of clearly defined areas. A good at-home activity is to work with your child in doing some follow-up (perhaps by use of the Web) on a topic your child has just studied at school.

It is important to think in terms of the levels of expertise from your child's point of view. For example, suppose your child asks for your help in pounding a nail or picture hook into the wall. Aha! A teachable moment, complete with intrinsic motivation. However, perhaps your child only wants to know enough about the use of a hammer to complete the task at hand. You might stretch this a little, giving your child the chance to gain an initial, low level of expertise in pounding nails. However, you certainly should not take this opportunity to immediately enroll your child in a shop class or apprentice your child to a carpenter.

## Chapter 6: Problem Solving in Different Disciplines

If I had eight hours to chop down a tree, I'd spend six sharpening my axe. (Abraham Lincoln)

The reason most kids don't like school is not that the work is too hard, but that it is utterly boring. (Seymour Papert)

Judge a man by his questions rather than his answers. (Voltaire)

Five thousand years ago, formal education focused mainly on the disciplines of reading, writing, and arithmetic. Over the years, many additional disciplines have been developed. For example, science is now an important discipline. Even in grade school, students will be exposed to ideas from a number of different science disciplines such as astronomy, biology, chemistry, environmental science, geology, and physics.

Each discipline of study has its own ideas on educational goals within the discipline. However, problem solving and other higher-order thinking tasks are a common theme in each discipline. This chapter introduces problem solving and roles of ICT in problem solving across many different disciplines.

### Problem Solving

Problem solving consists of moving from a given initial situation to a desired goal situation. That is, problem solving is the process of designing and carrying out a set of steps to reach a goal. Figure 6.1 graphically represents the concept of problem solving. Usually the term *problem* is used to refer to a situation where it is not immediately obvious how to reach the goal. The exact same situation can be a problem for one person and not a problem (perhaps just a simple activity or routine exercise) for another person.

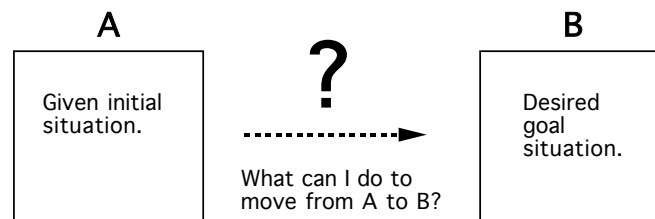


Figure 6.1. Problem-solving—how to achieve the final goal?

I use the term problem solving in a very broad sense. For me, *problem solving* includes dealing with:

- Question situations: recognizing, posing, clarifying, and answering questions.
- Problem situations: recognizing, posing, clarifying, and solving problems.
- Task situations: recognizing, posing, clarifying, and accomplishing tasks.
- Decision situation: recognizing, posing, clarifying, and making decisions.
- Using higher-order, critical, creative, wise, and forward-looking thinking to do all of the above.

Often the results from solving a problem are shared or demonstrated as a product, performance, or presentation.

### **What is a Problem?**

You have an intuitive understanding of what a problem is, and you solve problems all the time. Teachers find it useful to give a careful, formal definition of *problem* and to specifically teach problem solving in each discipline students study.

Here is a formal definition of the term *problem*. You (personally) have a problem if the following four conditions are satisfied:

1. You have a clearly defined given initial situation.
2. You have a clearly defined goal (a desired end situation). Some writers talk about having multiple goals in a problem. However, such a multiple goal situation can be broken down into a number of single goal problems.
3. You have a clearly defined set of resources that may be applicable in helping you move from the given initial situation to the desired goal situation. There may be specified limitations on resources, such as rules, regulations, and guidelines for what you are allowed to do in attempting to solve a problem.
4. You have some ownership—you are committed to using some of your own resources, such as your knowledge, skills, and energies, to achieve the desired final goal.

These four components of a well-defined (clearly-defined) problem are summarized by the four words: givens, goal, resources, and ownership. If one or more of these components are missing, you have an ill-defined problem situation (frequently called a problem situation or an ill-defined problem) rather than a clearly defined problem. An important aspect of problem solving is realizing when you are dealing with an ill-defined problem situation. In that situation, part of the problem-solving process is to transform the situation it into a clearly defined problem. Indeed, clarifying problem situations is one of the more important aspects of problem solving.

Consider some problem situations such as global warming, globalization of business, terrorism, homelessness, drugs, and the US students scoring below some other countries in international tests. These are all problem situations because the givens, guidelines, and resources are not specified. In addition, you may or may not happen to care about specific problems that relate to these problem situations.

Here is an example. Perhaps you care a great deal about whether your house is clean or messy, or whether your children pick up after themselves and keep their rooms clean. For you, these are clearly defined problems. However, perhaps your children do not view it that way. For them, these are not problems because they have no ownership.

There is nothing in the definition of problem that suggests how difficult or challenging a particular problem might be for you. Perhaps you and a friend are faced by the same problem. The problem might be very easy for you to solve and very difficult for your friend to solve, or vice versa. Through education and experience, a problem that was difficult for you to solve may become quite easy for you to solve. Indeed, it may become so easy and routine that you no longer consider it a problem.

People are often confused by the resources (component 3) of the definition. Resources merely tell you what you are allowed to do and/or use in solving the problem. Indeed, often the specification of resources is implied rather than made explicit. Typically, you can draw on your full range of knowledge and skills while working to solve a problem. However, you are not allowed to cheat (for example, steal, copy other's work, plagiarize). Some tests are open book, and others are closed book. Thus, an open book is a resource in solving some test problems, but is cheating (not allowed, a limitation on resources) in others.

People often have access to computers as they work to solve a problem. They draw upon both the capabilities of their mind/brain and of Information and Communication Technology (ICT) systems. They routinely make use of computational thinking as an aid to problem solving.

The idea of ownership is particularly important in teaching. If a student creates or helps create the problems to be solved, there is increased chance that the student will have ownership. Such ownership contributes to intrinsic motivation—a willingness to commit one's time and energies to solving the problem. All teachers know that intrinsic motivation is a powerful aid to student learning and success.

The type of ownership that comes from a student developing or accepting a problem that he/she really wants to solve is quite a bit different from the type of ownership that often occurs in school settings. When faced by a problem presented/assigned by the teacher or the textbook, a student may well translate this into, "My problem is to do the assignment and get a good grade. I have little interest in the problem presented by the teacher or the textbook." A skilled teacher will help students develop projects that contain challenging problems the students really care about.

### **Key Ideas in Problem Solving**

There are many books and learned articles about problem solving. I have written several books on the topic. The most recent is Moursund (2004) and it is available free on the Web. Here are a few very important ideas about problem solving:

1. Within any discipline, one can get a lot better at problem solving with the aid of informal or formal teaching, studying, and practice.
2. One of the most important ideas to problem solving is to build on the previous knowledge of yourself and others. The Web is a huge and rapidly growing library that is particularly useful in problem solving. "Look I up" is a good way to get started in attacking a very wide range of problems.
3. There are many general-purpose problem-solving strategies. Learning a few of them, and learning to make regular use of them, can greatly increase one's skill at solving problems. Here are two examples and a good reference.
  - a. Think and plan ahead. Before taking any steps to solve a problem, think about how the steps might help and the consequences of these steps.
  - b. Break large problems into a set of smaller, more manageable problems.
  - c. My book Moursund (2006) on games in education (available free on the Web) contains an appendix that lists and briefly discusses a couple of dozen of these types of strategies. The book teaches these strategies through uses of games at home and in school.

## **Working With Your Children and Their Schools**

One of the key ideas in this chapter is that problem solving lies at the very heart of every discipline. You have probably heard the expression, “looking at the world through rose-colored glasses.” Try looking at the world through problem-solving colored glasses. Whenever you encounter a problem-like situation, examine it more closely. Is it a clearly-defined problem? If so, mentally think through the given situation, the goal, the resources available to you, and how much you care about solving the problem.

As you get better at this, begin to teach your children this way of thinking. Help your children to understand how your mind works when you encounter a problem situation. Help your children learn some of the ways that you use to solve challenging problems. Place special emphasis on helping your children understand that the term *problem* means much more than just *math problem*.

You have some strategies that you commonly use when faced by a challenging problem. Think carefully about which of these strategies you want your children to learn. Then, openly discuss these strategies with your children, role model them in your day-to-day interactions with your children, and provide positive feedback when you witness your children making use of these strategies.

For example, perhaps you often face the problem of getting good quality at a fair and relatively low price when you shop. How do you solve this problem? Teach your strategies to your children. If you make use of the Web to do comparative price shopping, help your children learn to do this.

When talking to your children about what they have learned in school during the day and past week, ask them specifically about what problems they are learning to solve. Explore what they are learning from the point of view that problem solving is a major part of each discipline.

## Chapter 7: A Rapid Pace of Change

Don't worry about what anybody else is going to do. ... The best way to predict the future is to invent it. (Alan Kay)

"In times of change, the learner will inherit the earth while the learned are beautifully equipped for a world that no longer exists." (Eric Hoffer)

"Be the change you want to see in the world" (M. Gandhi)

Changes in science and technology are a major driving force fostering changes in societies and individual lives throughout the world. The pace of change in science and technology is increasing. Thus, your children will grow to adulthood and face adult responsibilities in a world that is considerably different from the way things were as you were growing up. Moreover, you, personally, face the challenge of living in this rapidly changing world.

Three key ideas help to capture what is happening:

1. The world continues to grow smaller—in the sense that improving telecommunication and transportation facilities bring us closer together.
2. The everyday problems and tasks people face grow more complex, and the information overload problem continues to grow.
3. Rapid progress continues to occur in the automation of many physical and mental tasks. Computers are playing a major role in both areas.

### The World is Getting Smaller

Walt Disney's Magic Kingdom popularized the song *It's a Small World* written by Richard M. Sherman and Robert B. Sherman. Here is a small piece of the song:

It's a small world after all

It's a small world after all

It's a small world after all

It's a small, small world

Probably the tune is now going through your head. If not, you can listen to the tune at <http://www.niehs.nih.gov/kids/lyrics/smworld.htm>. Want to learn more about Disneyland? Short video clips are available at <http://www.gofox.com/vacations/dlexplore.php?explore=Clips>.

I am still totally amazed when I can be reading a text document, click on a Web address and listen to related music, and click on another Web address and view and listen to related video.

However, the meaning of "It's a small world" was really brought home to me when I read Thomas L. Friedman's book, *The World is Flat: A Brief History of the Twenty-First Century* (Friedman, 2005). In this book, Friedman talks about how the Internet and inexpensive telephone services make it possible for many people to telecommute. He places considerable emphasis on

the number of people in India and other “far away” places telecommuting to jobs in the United States. He also emphasizes the off shoring and out sourcing of jobs.

The combination of telecommuting and worldwide competition in industrial manufacturing is changing the employment situation and competition for jobs. Friedman gives a poignant personal example of buying a new laptop computer at the time he was starting to write the “flat world” book. What happens for the company he bought from is as follows. Detailed (individualized) orders are electronically consolidated. Computer systems keep track of the various components that are needed, and make sure that they are being manufactured and delivered on time by about 30 different supplier companies from around the world. The laptops are assembled in a mass production manner in Malaysia, with each individualized to the specifications of a person’s orders. A week’s worth of orders from the United States (about 25,000 laptops) are loaded onto an airplane and flown to a UPS distribution point in the United States. The individual laptops are then delivered to their purchasers by UPS.

The various components were manufactured at factories that could provide needed quality at a competitive price, and meet delivery schedule requirements. Thus, the laptop might have a CPU manufactured in the US, memory manufactured in Korea, and various other components from a wide variety of other locations. While the final product is being sold to a US customer, most of the labor and materials come from outside the US.

Friedman’s book is particularly good in discussing the worldwide competition for jobs. Just the other day I read an article about people in the US flying to India to have hip replacement and knee joint replacement surgeries. These people do not have adequate insurance to cover the cost of such replacement surgeries in the US. They save a substantial amount of money—and still receive high quality services—by going to India.

The point is, you want your children to get an informal and formal education that helps to ensure gainful employment in a world where an increasing number of jobs are being off shored and/or out sourced.

### **The Pace of Change in Computer Technology**

It is hard to appreciate the pace of change in science and technology, and how it is affecting the world. Let’s consider the electronic digital computer. It was developed simultaneously in England, Germany, and the United states during World War II. In the United States, the first general purpose electronic digital computer became operation in early 1946. By 1951, the UNIVAC I was commercially available. It was sold to the US government and military, various businesses, and so on. Since then, the price to performance ratio for electronic digital computers has improved by a factor of about 10 billion.

Such a factor of change is so overwhelming it is nearly incomprehensible. One way to think about this is one dollar versus ten billion dollars. With today’s computers, a dollar’s worth of computing is about the same as ten billion dollars would have bought in 1952.

What this means is that you certainly do not want to become trained and educated for jobs that computers and automated manufacturing facilities can do well! A later chapter of this book discusses artificial intelligence. Computer systems are being developed that compete with and/or supplement the human brain, much like factory machinery and other machines compete with and/or supplements the human physical capabilities.

For those who like numbers, here is another tidbit of information:

In 1986, the Cray XMP-22 was replaced by a four processor Cray XMP-48. This system had 4 CPUs, 64 Mbytes of memory and a cycle time of 10.5 nanoseconds (112 MHz), with a theoretical peak performance of 800 Megaflops.

This machine cost about \$15 million and was among the world's fastest supercomputers. Now, about 20 years later, the medium-priced laptop computers or low priced desktop computers are more powerful than this supercomputer.

It isn't just the speed of computers that has changed so rapidly. Storage costs and connectivity also declined markedly. For example, in the early 1980s, a hard disk to be used with a microcomputer and that stored five megabytes of data cost about \$5,000. This was a dollar per megabyte. Now, hard disks cost less than 50 cents per gigabyte. Taking inflation into consideration this is factor of 5,000 improvement.

## **The Web**

It is difficult to talk about a pace of change when something that has not existed comes into existence and widespread use. The Web provides a good example of this. When you were a child, the World Wide Web did not exist. Now it is the world's largest library, it is a vehicle for buying almost anything, and it is a huge source of pornography.

Technological change has its plusses and its minuses. The Web makes possible online bookstores, so that you can buy a much larger range of books and at a lower price, as compared to using a local bookstore. However, the local bookstore may well be driven out of business. The very same Web that allows you to brows the great museums of the world provides others access to pornography. The same Web that is an important contributor to freedom of access to up-to-date information is a threat to governments that do not believe in freedom of information.

The Web makes possible online, interactive distance learning—which is just now beginning to produce significant changes in our precollege education system and higher education.

## **Cell Phones**

The Walkie Talkie of World War II fame was a predecessor to today's cell phone. Prior to the recent widespread developments of cell phone infrastructure, there were about a billion hard wired telephones in the world. Now, cell phone sales have reached a level of over .8 billion a year and estimates are that this figure will soon reach a billion a year. Today's modern cell phone is a picture phone that includes a built-in digital camera and connectivity to the Internet. It may well contain a GPS and a video camera. People use their cell phones to do email, browse the Web, play games, listen to music, exchange instant text messages, and watch videos. They also use them to disrupt others in theaters and classrooms, and to cheat on tests.

There are many parts of the world where the cell phone is ubiquitous (meaning, essentially everybody has one). How might cell phones change an education system? Let me make the question more complex. The cell phone is merely part of the change in telecommunications being made possible by computer technology, fiber optics, and other technological progress. You live, work, play, and parent in a world in which use of such technology is commonplace. You use ICT whenever it will help you to solve the problems and accomplish the tasks that you face.

To what extent should the same situation hold for students? Should their education include a substantial merger of routine use of these telecommunication systems? Should they receive instruction in how to make more effective use of the power of telecommunication systems?

## **Nanotechnology**

I first learned about nanotechnology (building ultra small devices, perhaps molecule by molecule, or even atom by atom) when I read Eric Drexler's 1986 on this topic. At that time, nanotechnology seemed like a pie-eyed dream. Now it is a multibillion-dollar industry, and it is growing very rapidly. The potentials are so large that a number of national governments have invested very heavily in supporting nanotechnology research, hoping to gain an advantage for their countries.

The United States Federal Government leads the world in nanotechnology research and development funding. The National Nanotechnology Initiative (NNI), the Federal Government's R&D program that coordinates multiagency efforts in nanotech science, allocates over \$1 billion [annually] to 14 agencies. Since its inception in 2000 it has been largely regarded a success. Most recently, the President's Council of Advisors on Science and Technology (PCAST) found that the funding is "very well spent," and that "the program is well managed." (Heller, 2005)

Nanotechnology will make possible still faster and smaller computers. It will make possible significant improvements in many current products, and it will lead to new products. Quoting from Wolfe (2005):

Our third annual Nanotech Product Guide reveals some interesting trends. The overwhelming majority of commercially-available nanotech products on the market today are in sports. Last year, we featured Nanogate/Holmenkol's Cerax Nanotech Ski Wax, Babolat Tennis Racquets using nanotubes and longer-lasting nanoparticle tennis balls from Inmat/Wilson. In 2004, sports led the way for nanotechnology commercialization yet again. From golf balls to footwarmers, athlete skin care to new tennis racquets (from Wilson, again), consumer demand for better exercise equipment and materials is still driving nanotech revenues.

## **Working With Your Children and Their Schools**

Spend a little time thinking about how well you are dealing with science and technology-based changes going on in the world. In the "good old days," a good measure of this was whether a person knew how to set the clock on a VCR or set the timer to record a TV program that comes on at a certain time.

Perhaps a more modern approach is to consider several areas in which you have a reasonable level of expertise. For example, you have a reasonable level of expertise in reading and writing in a non-computer environment, retrieving information from books, buying from local stores, playing non-electronic games, and so on. Now, think about your levels of expertise in doing the same things, but in ICT environments.

If you are keeping up with technology-based changes in entertainment, cell telephones, medicine, work requirements, and so on, then you are a good role model for your children. If you are feeling overwhelmed and are falling behind, then chances are you are not doing as well as you might in helping prepare your children for adult life in a rapidly changing world.

You know that schools are slow to change. It is unreasonable to expect that schools all by themselves, or your children all by themselves, will gain the knowledge and skills to function well in a fast changing world. You and your children must work together to supplement what the schools can do and what you children can do on their own.

## Chapter 8: Cognitive Developmental Scales

"Try to learn something about everything and everything about something." (Thomas H. Huxley)

"No computer has ever been designed that is ever aware of what it's doing; but most of the time, we aren't either." (Marvin Minsky)

There is steadily growing knowledge about how a person's brain and mind develops over the years. This development is strongly influenced both by "nature" and "nurture." Thus, children of the same age can have major differences in their level of cognitive development. Home and school make a huge contribution to a child's cognitive development.

Jean Piaget was one of the early pioneers in the study of cognitive development of children. Some of his ideas have stood the test of time, while others given way to more current progress in developmental theory research and brain science.

### Piaget's Developmental Scale

We know that the human brain changes quite rapidly during early years of life, and it continues fairly rapid change until a person is in their early to mid 20s. Jean Piaget's work on cognitive developmental theory contributed greatly to our understanding of stages of human development. (Piaget, n.d.). See Figure 8.1.

Approximate Age	Stage	Major Developments
Birth to 2 years	Sensorimotor	Infants use sensory and motor capabilities to explore and gain increasing understanding of their environments. If the environment (nurturing, food and vitamins, shelter, freedom from lead and other poisons, healthcare) is adequate beyond some modest threshold, then developmental progress is strongly dependent on genetic/biological factors.
2 to 7 years	Preoperational	Children begin to use symbols, such as speech. They respond to objects and events according to how they appear to be. Children make rapid progress in receptive and generative oral language. There are large advantages of growing up in a "rich" cultural and socioeconomic.
7 to 11 or 12 years	Concrete operations	Children begin to think logically. In this stage (characterized by 7 types of conservation: number, length, liquid, mass, weight, area, volume), intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects. Operational thinking—including mental actions that are reversible mental testing of ideas—begins to develop. Schools and schooling play a significant role in helping to shape a child's development during this stage.
11 or 12 years and beyond	Formal operations	Thought begins to be systematic and abstract. In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts.

#### 8.1. Piagetian cognitive development scale.

A child's rate of progress through the Piagetian developmental stages is dependent on both nature and nurture. Good home, neighborhood/community, and school environments make a huge difference (Piaget Society, n.d.).

The top end of the Piagetian developmental scale is called formal operations. An average student begins to move into this stage at age 11 or 12. In this stage, thought begins to be systematic and abstract, and intelligence is demonstrated through the logical use of symbols related to abstract concepts.

It is essential to understand that there is a substantial difference between beginning to move into the stage of formal operations, and actually achieving this level of development. Only about 35% of students in the United States achieve broad-based formal operations by the time they complete high school. Perhaps half of all adults never achieve a broad-based formal operations (Moursund, 2005b). However, research suggests that the majority of people do research formal operations in narrower areas—such as in a particular job. Years of on-the-job training, education, and experience helps a person learn to function quite well within the narrow confines of the job.

### Piagetian-type Developmental Scales in Specific Disciplines

It is possible to construct a Piagetian-type developmental scale within any discipline. Thus, we can talk about a child having a higher level of cognitive development in reading than in math. A child's natural abilities, intrinsic motivation, and interests and support of parents may lead to the child reaching formal operations in musical performance at a relatively early age.

About 50 years ago, the Dutch educators Dina and Pierre van Hiele focused some of their research efforts on defining a Piagetian-type developmental scale for Geometry (van Hiele, n.d.). Their five-level scale is shown in figure 8.2. Notice that the van Hieles, being mathematicians, labeled their first stage Level 0. This is a common practice that mathematicians use when labeling the terms of a sequence.

Stage	Description
Level 0 (Visualization)	Students recognize figures as total entities (triangles, squares), but do not recognize properties of these figures (right angles in a square).
Level 1 (Analysis)	Students analyze component parts of the figures (opposite angles of parallelograms are congruent), but interrelationships between figures and properties cannot be explained.
Level 2 (Informal Deduction)	Students can establish interrelationships of properties within figures (in a quadrilateral, opposite sides being parallel necessitates opposite angles being congruent) and among figures (a square is a rectangle because it has all the properties of a rectangle). Informal proofs can be followed but students do not see how the logical order could be altered nor do they see how to construct a proof starting from different or unfamiliar premises.
Level 3 (Deduction) Roughly speaking, this corresponds Piagetian Formal Operations Scale.	At this level the significance of deduction as a way of establishing geometric theory within an axiom system is understood. The interrelationship and role of undefined terms, axioms, definitions, theorems, and formal proof is seen. The possibility of developing a proof in more than one way is seen.
Level 4 (Rigor)	Students at this level can compare different axiom systems (non-Euclidean geometry can be studied). Geometry is seen in the abstract with a high degree of rigor, even without concrete examples.

Figure 8.2 Van Hiele five-level developmental scale for geometry.

The van Hieles' work suggested that the typical high school geometry course was being taught at a developmental level considerably above that of the typical students taking such courses. Think carefully about your math experiences as you took algebra and geometry courses in high school. Did some of this coursework seem over your head ("I just don't get it."), forcing you into memorize, regurgitate, and forget mode? The same general question applies to students

studying math at all grade levels. When students “just don’t seem to get it,” the chances are good that the content and the way it is being presented are at an inappropriate cognitive developmental level for the students.

It is evident that moving up the van Hiele geometry cognitive developmental scale requires learning quite a bit of school-math geometry. For most students, this means that progress in moving up this scale is highly dependent on their teachers and the math curriculum. The NCTM Standards list geometry as one of the major content strands, and indicate that geometry is an important part of the elementary school math curriculum (NCTM, n.d.). Thus, parents and elementary school teachers have the opportunity to make a major contributions.

### An ICT Cognitive Developmental Scale

Figure 8.3 contains an ICT cognitive developmental scale based on the ISTE National Educational Technology Standards (NETS) for students. There is a strong parallel between this scale and the Piagetian cognitive development scale. I consider this scale to be a work in progress, and I will undoubtedly make changes to it in the future. However, I feel that in its current form it is already quite useful. With appropriate home and school educational opportunities and encouragement, many students can achieve formal operations in ICT by the time they finish high school.

Stage “Title”	Age and/or Education Levels	Brief Discussion
Stage 1. Piagetian Sensorimotor.	Age birth to 2 years. Informal education provided by parents, and other caregivers.	<p>Infants use sensory and motor capabilities to explore and gain increasing understanding of their environments.</p> <p>ICT has brought us a wide range of sound and music-producing, talking, moving, walking, interactive, and developmentally appropriate toys for children in Stage 1. These contribute to general progress in sensorimotor growth and to becoming acquainted with an ICT environment.</p>
Stage 2. ICT Preoperational.	Age 2 to 7 years. Includes both informal education and increasingly formal education in preschool, kindergarten, and first grade.	<p>During the Piagetian Preoperational stage, children begin to use symbols, such as speech. They respond to objects and events according to how they appear to be. They accommodate to the language environments they spend a lot of time in.</p> <p>ICT provides symbols and symbol sets that are different from the speech, gestures, and other symbol sets that have traditionally been available. TV and interactive ICT-based games and edutainment are a significant environmental component of many children during Stage 2. During this stage, children can develop considerable speed and accuracy in using a mouse, touch pad, and touch screen to interact and problem solve in a 3-dimensional multimedia environment displayed on a 2-dimensional screen.</p>
Stage 3. ICT Concrete Operations.	Age 7 to 11 or 12 years. Includes informal education and steadily increasing importance of formal education at grades 2-5 in elementary school.	<p>During the Piagetian Concrete Operations stage, children begin to think logically. In this stage, intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects. Operational thinking (mental actions that are reversible) develops. ISTE has established NETS-Student that includes a statement of what students should be able to do by the end of the fifth grade. During the ICT Concrete Operations stage children:</p> <ul style="list-style-type: none"> <li>• Learn to use a variety of software tools such as those listed in the 5<sup>th</sup> grade ISTE NETS-Student, and begin to understand some of the capabilities and limitations of these tools. (They do logical and systematic manipulation of symbols in a computer environment.)</li> <li>• Learn to apply these software tools at a Piagetian Concrete Operations level as an aid to solving a wide range of general curriculum-</li> </ul>

		appropriate problems and tasks.
Stage 4. ICT Formal Operations.	Age 11 or 12 and beyond. This is an open ended developmental stage, continuing well into adulthood. Requires ICT knowledge, skills, speed, and understanding of topics in ISTE NETS for students finishing the 12 <sup>th</sup> grade.	<p>During the Piagetian Formal Operations stage, thought begins to be systematic and abstract. In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts.</p> <p>Formal Operations in ICT includes functioning at a Piagetian Formal Operations level in specific activities such as:</p> <ol style="list-style-type: none"> <li>1. Communicate accurately, fluently, and with good understanding using the vocabulary, notation, and content of ISTE NETS-S for the 12<sup>th</sup> grade.</li> <li>2. Given a piece of software and a computer, install and run the software, learn to use the software, explain and demonstrate some of the uses of the software, save a document you have created, and later return to make further use of your saved document.</li> <li>3. Problem solve at the level of detecting and debugging hardware and software problems that occur in routine use of ICT hardware and software.</li> <li>4. Convert (represent, model, pose) real world problems from non-ICT disciplines into ICT problems, and then solve these problems.</li> <li>5. Routinely and comfortably use ICT in the other disciplines you have studied, at a level consistent with and supportive of your cognitive developmental level in these disciplines.</li> <li>6. Have a conceptual understanding of similarities and differences, and capabilities and limitations, of human mind/brain versus ICT systems. Work comfortably and competently with ICT systems as auxiliary mind/brains.</li> </ol>

Figure 8.3. ICT cognitive developmental and expertise scale.

Notice the generality of this ICT cognitive developmental scale. It does not speak to specific brands of hardware and pieces of software. It is inherent to the scale that moving up the scale requires learning to learn ICT and to apply what one has learned. It requires gaining a broad range of skills and increasing confidence in handling the problems that are inherent in using “buggy” ICT hardware and software systems.

**Working With Your Children and Their Schools**

As a parent, you can make a huge contribution to your child’s early years of cognitive development. You can make such contributions both in general (for example, see Figure 8.1) and in any particular discipline or sub discipline (see Figures 8.2 and 8.3).

In all cases the goals are to emphasis higher-order thinking and problem solving. Memorize and regurgitate is a useful part of education. However, understanding, thinking, and dealing with challenging problems are the critical parts of moving toward formal operations. Thus, as you talk with your children about what they are learning in school and at home, place the greatest emphasis on understanding, thinking, and solving challenging problems. In such conversations, explore what they are learning about uses of ICT in representing and solving the problems in the various disciplines they are studying.

## Part 3: Brain and Mind Science

### Brief Summary of Part 3

We all grow up in a world that makes routine use of tools designed to supplement and extend our physical capabilities. When you are going barefooted and step on a sharp rock, you appreciate the value of shoes. When you face the cold of a winter blizzard, you appreciate the value of warm clothing and a warm shelter. You probably make routine use of various aids to transportation, such as bicycle, car, train, and airplane. You are aware of telescopes and microscopes that extend human visual capabilities.

Most people are less consciously aware of aids that have been developed to supplement and extend the capabilities of our brains. That is partly because we do not think of reading, writing, and arithmetic as brain tools. However, they are powerful brain tools and they have proven to be powerful change agents.

Factory automation can be thought of as combining aids to one's physical capabilities and aids to one's mental capabilities. Such automation began long before we had computers. However, computers are a powerful aid to factory automation, as they increase the level of "machine intelligence" that can be made available to direct automated tools.

A simple definition of a computer is that it is a machine for the input, storage, manipulation, and output of information. A computer is an information-processing machine that can quickly and accurately follow a detailed step by step set of instructions called a computer program. In factory automation, a computer can direct a set of machines to carry out various operations on parts that are being manufactured and assembled. Using different programs, the same or other computers can collect and process payroll information, prepare invoices, and carry out a variety of accounting functions.

The mass production of electronic digital computers in the early 1950s. By the mid 1950s, some people were beginning to explore machine intelligence or artificial intelligence. The term artificial intelligence came into general use in the United States, while the term machine intelligence came into general use in Europe.

The development of computers and the field of artificial intelligence has contributed to the study of human intelligence. The chapters in Part 3 explore a variety of human and machine intelligence topics from an ICT in education point of view. The main theme is helping students gain an education in which they learn to effectively use their own brains and the capabilities of artificial intelligence to help solve challenging problems and accomplishing challenging tasks. A key idea to hold in mind is that the rate of improvement in machine intelligence is quite high and is accelerating.

## Chapter 9: Information and Problem Overload

When you are up to your neck in alligators, it's hard to remember the original objective was to drain the swamp. (Adage)

The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom." (Isaac Asimov, Isaac Asimov's Book of Science and Nature Quotations, 1988)

The key to increasing one's expertise in a discipline is to increase one's ability to understand, represent, and solve the types of problems in the discipline. Researchers and practitioners in each discipline contribute to the expansion of their disciplines.

In general, each discipline of study and research tends to become larger and more complex over time. It is useful to think of the growth of a discipline as a growth in both information and problems within the discipline. The rate of growth in information and problems may be overwhelming. Thus, a person working within a discipline may well face both an information overload and a problem overload.

The information and problem overload can easily overwhelm a person working to develop and/or maintain a high level of expertise in a domain. It certainly tends to overwhelm people who want and need only a modest level of expertise within a particular discipline.

### Information Overload

Figure 9.1 includes brief definitions of the terms data, information, knowledge, wisdom, and foresight.

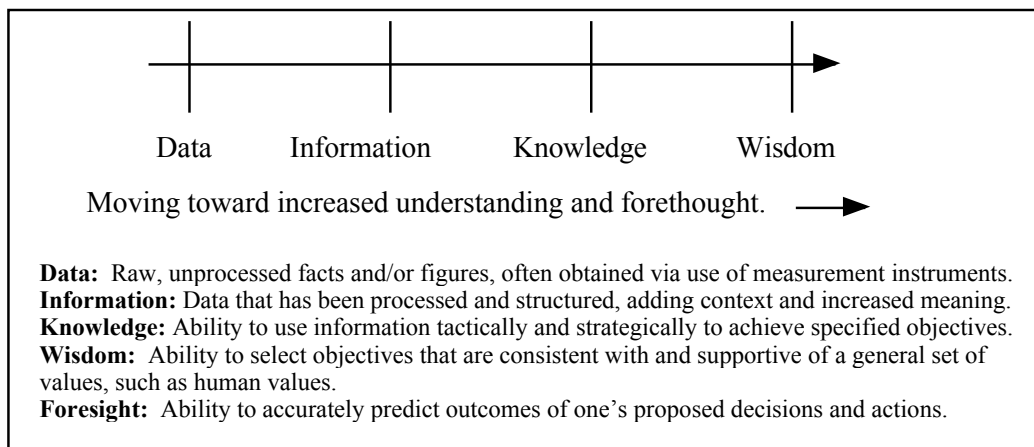


Figure 9.1. Definitions of data, information, knowledge, wisdom, and foresight.

As a discipline grows and matures, it gains in depth and breadth in terms of accumulated results and the problems it addresses. The data, information, knowledge, and wisdom in the discipline grow. People often the term *information* to refer to this accumulated data, information, knowledge, and wisdom. (This is, of course, somewhat confusing, as the term information is used as part of the definition of this definition of information!)

Here is a definition quoted from the Wikipedia:

**Information overload** refers to the state of having too much information to make a decision or remain informed about a topic. This term is usually used in conjunction with various forms of computer-mediated communication such as electronic mail. Large amounts of currently available information, a high rate of new information being added, contradictions in available information, a low signal-to-noise ratio, and inefficient methods for comparing and processing different kinds of information can all contribute to this effect.

Notice the stress on decision making and on keeping up (remaining well informed) in a particular area. Consider the plight of a general practitioner doctor who makes many medical decisions during a day of seeing a steady stream of patients. These decisions are efforts to help solve patients' medical problems. Often a decision is made to refer the patient to a specialist. This means that a PG needs to have both depth and breadth of medical competence. However, there are hundreds of thousands of medical research articles published each year. The U.S. National Library of Medicine, the largest medical library in the world, added more than 600,000 new articles to its index in 2005. There is no way that a person can read this volume of literature and gain a needed level of understanding and foresight.

### Quality of Information

Let's begin with a personal example. I am writing a book chapter that includes the topic **information overload**. I go to Google and do a search on the quoted term "*information overload*" and get more than 3 million hits. That is, Google identifies more than 3 million documents in which the two-word phrase *information overload* occurs. Google also orders these hits on the basis of possible relevance. Of course, Google cannot read my mind, so its order of relevance may not agree with how I would order the documents.

I am now faced by the problem of extracting the information that I need from the 3 million hits. Some may have been written by highly qualified scholars and published in refereed journals. Others may be newspaper and magazine articles, written by people with very little insight into how ICT is changing the world. Still others may have been written by people who have an "ax to grind," and may be heavily biased or full of completely incorrect information.

The top item in my Google-supplied list was the Wikipedia article quoted in the previous section of this chapter. The definition given in that article is consistent with my insights into information overload, and it is better written than I could have done. By putting in as quoted material rather than rewriting it in my own words, I believe I have increased the quality and believability of this chapter.

I browsed the first part of the next two hits, and they did not seem useful. The fifth hit took me to a Website I have used before, that discusses the world's total yearly production of information distributed in print, film, magnetic, and optical media. Quoting <http://www2.sims.berkeley.edu/research/projects/how-much-info-2003/execsum.htm>:

[The world] produced about 5 exabytes of new information in 2002. Ninety-two percent of the new information was stored on magnetic media, mostly in hard disks.

How big is five exabytes? If digitized with full formatting, the seventeen million books in the Library of Congress contain about 136 terabytes of information; five exabytes of information is equivalent in size to the information contained in 37,000 new libraries the size of the Library of Congress book collections.

...

We estimate that the amount of new information stored on paper, film, magnetic, and optical media has about doubled in the last three years.

I have confidence in the quoted material because of the reputation of the organization publishing the study and because the methodology for gathering and analyzing the data is given.

I browsed the next dozen Google hits, but did not find anything that seemed worth of adding to this short chapter. Notice my approach to this information overload problem. I was able to quickly and briefly scan the first part of perhaps 20 documents. (Think about how long it would take to go to a physical library and accomplish a similar task!) My relatively high speed Web connection meant that little time was wasted retrieving these documents. My knowledge of the field allowed me to make quick decisions of whether a document seemed both reliable and useful to me. In making these quick decisions, I am drawing upon years of education, training, and experience. Through these years of effort, I have developed a reasonably high level of expertise in processing and making use of Web-based information.

### **Problem Overload**

Like many of you, I watch quite a bit of television. I see a large number of ads that are roughly as follows:

1. Here is a problem that you have.
2. Buy and use our product and your problem will be solved.

I watch many news broadcasts. These present many different local, regional, national, and international problem situations. Often, these make me feel dispirited and overwhelmed.

Even without television, however, my everyday life is full of decisions that I face—decisions that I might make or I might ignore. For example, I go grocery shopping. Even within the specific list of items that I need, there are many different choices (decision to make). In addition, I am exposed to a huge number of different products that are designed to catch my attention and seem appealing. I must make decisions about each of these.

When income tax time rolls around each year, I am faced by the problem of doing my state and federal income taxes. By far the most difficult part of solving this problem is gathering, organizing, and saving appropriate records (information) throughout the year.

However, there is a specific difficulty of dealing with tax laws that change appreciably from year to year. I can try to figure these out by myself, hire someone who is a professional in the field, or make use of an artificially intelligent computer program designed to help me do my income tax. Interesting! I, and many millions of other people, chose to make use of a tax preparation program. These types of programs contain built-in intelligence that incorporates the latest income tax laws. The program I use guides me through the tax preparation process, does a little teaching, answers some questions, and does a huge amount of busybody work, including all of the necessary calculations and filling out the forms.

I routinely deal with a host of other problem situations and specific problems. For example, I deal with medical problem situations, insurance problems situations, retirement problem situations, financial problem situations, car and home appliance repair problem situations, and lawn and garden care problem situations. I deal with a host of people (grandchildren, children, friends, acquaintances, neighbors, professional colleagues, student, and so on) problem situations,

In each problem domain, I have a certain level of expertise. Sometimes this level of expertise is sufficient to understand and solve a particular problem. Sometimes I make use of my computer as an aid to solving the problem. Sometimes I hire a person with the expertise needed to solve the problem. Over the years, I have developed enough expertise in dealing with life's problems so that I usually do not feel overwhelmed.

### **Working With Your Children and Their Schools**

Your children are growing up in a world that is apt to challenge them with both information overload and problem overload. These two types of overload are closely related and a natural outcome of the progress each discipline is making. The development of new disciplines and sub discipline (such as nanotechnology, biological cloning, non invasive body and brain scanning equipment) contributes to the challenges people face.

Here is a general set of guidelines that you can learn for yourself and help your children to learn:

1. Learn the difference between a problem situation and a personal problem. In a personal problem, you have ownership and are willing to commit your personal resources (time, money) to solve the problem. As an example, in most case information overload may be merely a problem situation rather than a personal problem that you accept and must solve.
2. Through informal and formal education, develop an initial level of expertise that allows you to understand the various types of problems you face. Learn to distinguish between an "I want" problem situation and an "I really need" problem situation.
3. Learn how to gain more data, information, knowledge, wisdom, and foresight in the various disciplines that contain the problem situations and problems you routinely encounter. That is, learn to learn in these disciplines and learn to make effective use of information retrieval in these disciplines.
4. Learn that you are likely to routinely encounter problems where you need the help of other people, the help of computer systems (perhaps artificially intelligent computer systems, or both). Learn to effectively use these resources.

You can help your children to understand and make use of the above ideas through your personal role modeling and through routine conversations with your children.

## Chapter 10: Human Intelligence

“When you spoke of a nature gifted or not gifted in any respect, did you mean to say that one man may acquire a thing easily, another with difficulty; a little learning will lead the one to discover a great deal; whereas the other, after much study and application, no sooner learns than he forgets...” (Plato, 4<sup>th</sup> century B.C.)

Your brain has tremendous capabilities, but it also has some severe limitations. This chapter explores human intelligence from an education point of view. The next chapter covers artificial intelligence, which is also called machine intelligence. It is important that students, parents, and teachers understand some of the major similarities and differences between human intelligence and machine intelligence.

During the past two decades, study of the human brain has been greatly aided by progress in the development of computerized brain scanning systems. Progress in brain science is beginning to produce results that are useful to educators. A Google search on 8/3/06 using the expression *brain science and education* produced more than 70 million hits.

### The Human Brain

I believe you will enjoy looking at Nitin Gogtay et al. (2004). It contains some excellent brain scan pictures of human cortical development during ages 4-21. One of the things that I found interesting in the brain research literature is that the human brain is nearly full size by age five, but continues to change internally at a rapid rate for many years thereafter. Indeed, a typical human brain reaches doesn't reach full maturity until approximately age 25.

Learning is essentially a process of growing new connections among neurons and strengthening existing connections. The human brain has considerable plasticity. In addition, new neurons are developed throughout life (Lehrer, 2006). Your brain is highly adaptable, able to learn and to adjust to a certain amount of damage throughout life. For example, here is a brief quote from Human Brain (n.d.):

Functional MRI (magnetic resonance imaging) studies reveal the brain's innate plasticity—its ability to reprogram itself after stroke. This highly complex organ adapts to injury by redistributing its cognitive workload across established neural networks, and recruiting different brain areas to fill in for lost functions.

However, here is an important warning: **“Use it or lose it.”** A good analogy is to compare a brain to a muscle. If you don't use a muscle, it weakens and atrophies. The same holds true for a brain. A mental couch potato's brain goes down hill roughly like a physical couch potato's muscles go down hill.

### Intelligence (A Non-technical Discussion)

Here is a definition of intelligence that I have developed through study of the literature, and that I find useful in my teaching and writing. Intelligence is a combination of the abilities to:

1. Learn. This includes all kinds of informal and formal learning via any combination of experience, education, training, introspection, learning on your own, and so on.

2. Pose problems. This includes recognizing problem situations and transforming them into more clearly defined problems.
3. Solve problems. This includes solving problems, accomplishing tasks, and fashioning products, performances, and presentations.

Notice the emphasis on solving problems. The typical human brain has a tremendous capability of getting better at problem solving. As indicated in previous chapters, increasing expertise in any discipline requires considerable time and effort. The rate of increase is affected by a variety of factors such as intrinsic motivation, quality of instruction and coaching, and a person's intelligence.

The terms ability, aptitude, and intelligence are closely related. Intelligence and measures of intelligence have been extensively studied for more than a hundred years. Quoting from Gottfredson (1998):

The debate over intelligence and intelligence testing focuses on the question of whether it is useful or meaningful to evaluate people according to a single major dimension of cognitive competence. **Is there indeed a general mental ability we commonly call "intelligence," and is it important in the practical affairs of life? The answer, based on decades of intelligence research, is an unequivocal yes. ... Intelligence as measured by IQ tests is the single most effective predictor known of individual performance at school and on the job.** [Bold added for emphasis.]

### General Intelligence (A More Technical Discussion)

Considerable research over the past century has supported the idea that IQ tests tend to measure a common factor called *g*, for general intelligence (Gottfredson, 1998). General intelligence (*g*) can be divided into two major components or factors: fluid intelligence (*Gf*) and crystallized intelligence (*Gc*). Quoting from Healy & McNamara (1996):

The first common factor, ***Gf***, represents a measurable outcome of the influence of biological factors on intellectual development (i.e., heredity, injury to the central nervous system), whereas the second common factor, ***Gc***, is considered the main manifestation of influence from education, experience, and acculturation.

While a person's level of fluid intelligence tends to peak in the mid 20s, growth in crystallized intelligence may continue well into the 50s. Since the rate of decline in fluid intelligence over the years tends to be relatively slow, a person's total cognitive capabilities can remain high over a long lifetime. Current research strongly supports the idea of "use it or lose it" for the brain/mind, as well as the rest of one's body. (Goldberg, 2005; Memory Loss, 2004.)

### Intelligence Quotient (IQ)

You know that children get smarter and more intellectually able as they get older. Intelligence Quotient (IQ) measures take this into consideration. IQ is a measure of a person's intelligence divided by their age. Consider a seven year old and a 14 year old, each having an IQ of 100. The 14 year old has scored twice as high as the seven year old on the IQ test.

Figure 10.1 shows a normal curve with the shaded area representing the area between the mean and +1 standard deviation. Several commonly used IQ tests have a mean of 100 and a standard deviation of 15. For such tests, 34% of people score in the range of 85 to 100, and 34% score in the range of 100 to 115.

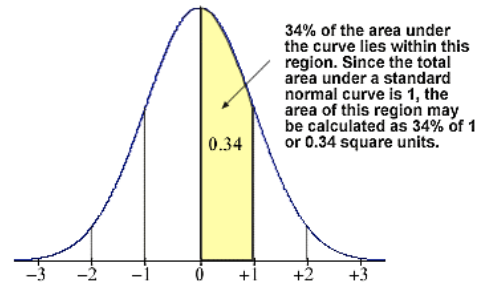


Figure 10.1. Normal distribution curve.

IQ is often used in discussing a person's intelligence. The study of intelligence has a long history (History, n.d.). Detterman (2005) provides a very nice overview of the field. His article includes a discussion about how IQ test scores have been rising over the past few decades.

It appears that people are getting smarter [over the past 50 years]. However, only some tests show these changes. Tests of visual-spatial reasoning, like the Raven's test, show the largest changes, while vocabulary and verbal tests show almost no change. Some psychologists believe that people are not really getting smarter but are only becoming better test takers. **Others believe the score gains reflect real increases in intelligence and speculate they may be due to improved nutrition, better schooling, or even the effects of television and video games on visual-spatial reasoning.** [Bold added for emphasis.]

Notice the bolded part of the above quote. This suggests how nurture can help develop the inherent abilities of a person. Another possible reason why IQ is increasing is that we now understand that lead poisoning, mercury poisoning, many other pollutants, lack of needed vitamins, and malnutrition all reduce intelligence.

## Rate of Learning

Likely, you have an intuitive understanding that a person with above average IQ tends to learn faster and better than a person with below average IQ. Suppose, for example, that we are looking at a student with an IQ of about 65-70 (about two standard deviations below average) and another student with an IQ of about 130-135 (about two standard deviations above average). Then research suggests (on average) that the first student will learn at less than one-half the rate of an IQ 100 student, while the second student will learn at more than twice the rate of the IQ 100 student. That is, the more intelligent student may well learn at more than four times the rate of the less intelligent student, and will learn considerably better.

The following quoted material provide information about the rate of learning of slow versus fast learners (Gottfredson, 1998):

High-ability students also master material at many times the rate of their low-ability peers. Many investigations have helped quantify this discrepancy. For example, a 1969 study done for the U.S. Army by the Human Resources Research Office found that enlistees in the bottom fifth of the ability distribution required two to six times as many teaching trials and prompts as did their higher-ability peers to attain minimal proficiency in rifle assembly, monitoring signals, combat plotting and other basic military tasks. **Similarly, in school settings the ratio of learning rates between "fast" and "slow" students is typically five to one.** [Bold added for emphasis.]

## Multiple Intelligences: Howard Gardner

The study of general intelligence (g) has a long history and it remains a key idea in the field. However, many researchers have argued that a human brain has many different kinds of intelligences. In the past 20-some years, Howard Gardner has been the most influential of these

people. In 1983, he published his first book on Multiple Intelligences . He currently believes that a person has at least eight distinct areas of intelligence (Gardner, 2003):

- Linguistic intelligence ("word smart"):
- Logical-mathematical intelligence ("number/reasoning smart")
- Spatial intelligence ("picture smart")
- Bodily-Kinesthetic intelligence ("body smart")
- Musical intelligence ("music smart")
- Interpersonal intelligence ("people smart")
- Intrapersonal intelligence ("self smart")
- Naturalist intelligence ("nature smart")

Many educators have found this theory quite appealing. A variety of people have argued for possible additions to the list. For example, Michael Posner's research on attention provides strong evidence that attention is an aspect of intelligence and should be added to the list (Posner, n.d.). Research suggests that attention is something that can be improved by appropriate education/training; computer software is being developed to do this.

### **Working With Your Children and Their Schools**

There has been considerable research on linguistic development during a child's preschool years. Parents who talk with and read to their children a lot are giving their children a tremendous advantage over children raised in homes that do not provide these types of linguistic environment. Children raised in a home environment that does not emphasis two-way verbal communication, vocabulary building, and reading oriented activities tend to enter kindergarten or first grade a full year or more behind other students. They face an uphill battle throughout their years of formal schooling.

Our formal educational system tends to place most of its emphasis on developing a child's linguistic and logical-mathematical intelligences. Largely, a child's cognitive development in the other areas in Howard Gardner's list is left up to the home, community, and child. Thus, there is a huge opportunity for a parent to make a significant contribution to a child's development.

You might want to pay particular attention to the current roles of ICT in art and music. In art, for example, think about the roles that computers now play in the graphic arts, computer animation, and video special effects. In music, think about music synthesizers, and composing and editing music at a computer keyboard. Most schools are not taking advantage of these computer capabilities that are now routinely used in outside-of-school settings.

## Chapter 11: Artificial Intelligence

The real problem is not whether machines think but whether people do.  
(B.F. Skinner, *Contingencies of Reinforcement*, 1969)

Artificial intelligence is a discipline in which people develop computers systems that can solve problems people find mentally challenging.”

An inexpensive solar-powered hand held calculator “knows” how to do long division and to extract square roots. An inexpensive electronic digital watch “knows” the time of day, day of the week, and so on. In some sense, each of these tools might be said to have some intelligence.

How about a computer system that is more accurate than most physicians in carrying out certain types of medical diagnosis, or a computer system that is faster and more accurate than most human experts in processing loan applications? The field of artificial intelligence is developing more and more computer systems that do quite well in solving problems and accomplishing tasks that previously required significant levels of human intelligence.

### Introduction to Artificial Intelligence (AI)

AI is concerned with developing computer systems that can store data, information, knowledge, and wisdom, and effectively use its computational and storage capabilities to solve challenging, complex problems.

A human brain is both a storage unit and a processing unit. Somewhat similarly, and computer has both storage and processing capabilities. However, the analogy quickly breaks down as we compare human intelligence with current levels of computer machine understanding.

The scale in Figure 9.1 includes brief definitions of the terms data, information, knowledge, and wisdom. Moving up this scale requires an increasing level of understanding and foresight.

Certain types of understanding and foresight can be built into a computer system. For example, a computer controlling the air conditioning and heating system in a building “knows or understands” the conditions under which it is to turn off the heating system and turn on the air conditioning system. It has the foresight to “realize or understand” that this will change the temperature so that it will be in a specified range.

Contrast this with a human who notes, “I am beginning to sweat. It must be too hot in here. I’m going to turn on the air conditioner.” The human has human understanding and foresight, and the computer has computer understanding and foresight. The human has a type of consciousness and self-awareness that is quite different than that of an AI system. However, both might well be faced by the same problem and solve it in the same manner.

You might wonder whether a computer can have knowledge or be knowledgeable. Currently, many large corporations include employees whose work is to use computers to transform data and information into knowledge. My 8/06/06 Google search on the quoted term “*knowledge engineering*” produced more than 3 million hits. In 2006, the Association for Computing Machinery held its 12<sup>th</sup> annual conference on this discipline (SKIDD, n.d.).

AI systems now routinely make or are used to help make data based, information based, and knowledge based decisions. However, many people believe that just because decisions are based on data, information, and knowledge, that does not mean they are wise decisions. Looking back

at Figure 9.1, you can see the short definition: Wisdom is the ability to select objectives that are **consistent with and supportive of a general set of values, such as human values.**

Suppose that you are faced by the problem of deciding whether your child should get a weekly allowance, and how much that allowance should be. A good decision depends on a great many variables. What type of fiscal and other maturity does your child display? How will an allowance contribute to your child becoming more responsible, fiscally and otherwise? Do you want to tie the allowance to certain types of “good” behavior and taking responsibility for helping around the home? It is not easy to make a wise decision that is apt to support the values that are important to you and achieve the long-term goals you want to achieve.

An AI computer system can be programmed to take into consideration a variety of rules that bear some similarity to having understanding, wisdom, and foresight. However, these are a far cry from what most people would consider appropriate in handling a difficult problem such as is described above. Remember, human intelligence and AI may appear to be solving the same problem and producing similar results, but human intelligence and AI are quite.

### **Sources of an AI System's Data, Information, and Knowledge**

Since the development of writing, there has been a steady accumulation of human-developed data, information, knowledge, and wisdom. When this accumulation is stored in books and other hard copy documents, it is static. It is not able to do anything by itself. Humans learn to read, understand, and make use of the (static) stored data, information, knowledge, and wisdom.

Computers have changed this situation. A computer can be programmed to act upon what it has stored in its memory units. For example, a computer system in a building can gather data about the weather outside the building, the number of people in the building (producing heat), the number of lights that are on (producing heat), and the temperature in various locations in the building. It can be programmed to combine this data with stored information about capabilities of the heating and air conditioning system and desirable temperature levels. The computer system can be programmed to make and implement decisions to control the building's climate.

Some people feel comfortable in arguing about the limitations of AI by making statements such as “the intelligence is all in the programming, and that is done by humans.” Actually, the situation is more complex than this. For one thing, there may be hundreds of researchers, analysts, and programmers involved in a large AI project. Thus, the AI program reflects the intelligence of hundreds of people working together.

Moreover, once an AI system comes into use, it can be improved by a careful analysis of the results it produces. The system may well be programmed to do this analysis by itself and make changes to its programming—thus improving itself.

This idea has been around for a long time. For example, it was used about 50 years ago in the development of some of the early computer chess-playing programs. A computer program is developed to play chess. It has a number of parameters or decision-making mechanisms that can be changed to improve the quality of play. These parameters are initially set by the humans developing the program. However, the program is written so that the computer itself can adjust the parameters based on its game playing experience. The computer is then set to playing against a second computer—perhaps one initially using the same program. Based on the results, the first computer changes its own parameters to increase its quality of play. After a number of games, perhaps the first computer stops getting better. The second computer is then provided with the

(improved) program developed by the first computer, and the process is repeated. Thus, over time, the first computer “learns” to be a better chess player.

For a more modern example, consider an AI system designed to read electrocardiograms. Its initial learning is programmed in. Its second level of learning comes from providing the computer system with lots of examples of electrocardiograms, the initial diagnosis done by human experts, and the later information found through further tests, treatment, and perhaps autopsy. The computer analyzes this information in order to improve its level of performance. A third level of learning comes from data mining—having the computer system examine the overall medical records of tens of thousands of patients who had electrocardiogram data gathered at some time in their lives. The computer system looks for patterns, and perhaps finds previously unknown relationships between electrocardiogram data and other medical problems. That is, the AI computer system actually makes new discoveries!

### **Alan Turing and the Turing Test**

The field of AI has come a long way since the development of the first electronic digital computers. However, competing with human intelligence has proven to be a formidable challenge. An average human is very intelligence relative to the very best of AI systems. For example, a first grader can understand a natural language and carry on a meaningful conversation. This is well beyond current AI systems.

Alan Turing (1912-1954) was a very good mathematician and a pioneer in the field of electronic digital computers. In 1936, he published a math paper that provides theoretical underpinnings for the capabilities and limitations of computers. During World War II, he helped develop computers in England that played a significant role in England's war efforts. In 1950, Alan Turing published a paper discussing ideas of current and potential computer intelligence, and describing what is now known as the Turing Test for AI (Turing, 1950)

The basic idea is that a person (the tester) carries on a written conversation with a computer and with a person located in another room. The computer is programmed to carry on a conversation in which it pretends to be a human. The goal is for the tester to distinguish between the human respondent and the computer.

In his 1950 paper, Turing predicted that by the year 2000 there would be computers that routinely fooled humans in this imitation game task. Interestingly, the field of AI has not yet passed Turing's Test. A prize has been established and yearly contests are held to see if a computer program has been developed that can pass the test (Loebner Prize, n.d.). At the current time, humans are far better than computers at carrying on a written conversation. Moreover, humans far exceed computers carrying on an oral conversation.

It is fun to play with some of the computer programs developed to compete for the Loebner Prize. Such programs are often called chatterboxes. Go to <http://en.wikipedia.org/wiki/Chatterbot> to read about chatterboxes and to access some examples of such AI systems.

### **A Symbiotic Combination of Human and Artificial Intelligence**

We are all used to the idea of people working with machines that enhance and supplement their physical capabilities. The same thing has been going on for many years in terms of humans and AI machines working together. For example, while I was writing this book, I was making use of a relatively sophisticated word processor. The spelling and grammar checker parts of this

word processor make use of AI. From time to time, I did a Web search, using the Google search engine. This search engine makes use of AI.

However, our educational system still has a strong resistance to allowing people and AI systems to work together in demonstrating their combined knowledge and skills. We want students to learn to make appropriate use of computers in the disciplines they are studying in school. At the same time, very few teachers allow students to take "open computer" tests. For some reason, many people consider that this would be cheating. This is despite the fact that this is the ordinary, adult-world reality of many jobs.

Interestingly, it took about 20 years before people began to be comfortable with the idea that it is okay to use a calculator when taking most state and national tests. It will be interesting to see how long it takes before computers and access to the Internet are considered acceptable when taking tests!

### **Working With Your Children and Their Schools**

The capabilities of AI systems and automated machines making use of AI will continue to improve in the future. AI and automation making use of AI have already led to substantially changes many jobs. However, AI aids to teaching and learning, along with AI as part of what one learns, and as an aid to making use of one's learning, have made only a tiny contribution to our current educational system.

As a parent, you want your children to get an education that helps prepare them for productive and satisfying life in the world they will live in as adults. This world will certainly include telecommuting, out sourcing of jobs, and off shoring of jobs. It will include a steady increase in aids to the human physical body and the human brain. AI will have a steadily increasing influence on life in our society.

Over time, there will be more and more things that AI systems can do better than people. A good modern education might include a strong focus on:

1. Learning to work effectively with AI and other ICT systems.
2. Gaining knowledge, skills, wisdom, understanding, insights, values, and foresight that is uniquely human.

You can help your children get such an education by working with them at home and by encouraging this type of education in the schools your children attend. As you talk with your children and their teachers, explore what children are learning about the capabilities of computers to do or help do the things students are learning to do by hand. Explore whether your children are getting an education that prepares them to work effectively with artificially intelligent machines, or with the emphasis is on learning to do things in competition with such machines.

## Chapter 12: Science of Teaching and Learning

“They know enough who know how to learn.” Henry Brooks Adams

A newborn child's brain is designed to learn and to make use of what it learns. A physically and mentally fit newborn child has the abilities to learn to communicate orally and to handle the types of learning required in a hunter-gatherer society.

The development of reading, writing, arithmetic, and a steady stream of new technology challenges human learning capabilities. I have always been somewhat amazed a child is able to learn reading, writing, arithmetic and higher math, and to deal with the complexities of life in our current world.

Many researchers and practitioners have studied teaching and learning, and how to make them more effective. This chapter explores a few key ideas about the *science of teaching and learning* (SoTL).

### Learning to Learn

While some people learn faster and better than others, we are all quite good at learning. We are all lifelong learners.

There has been quite a bit of research on how to help students learn faster and better. All of this work is part of the growing science of teaching and learning. Somewhat surprising to me is that our educational system **has not** done a good job of translating SoTL theory into practice. Our schools place only a modest emphasis on learning to learn and developing good study skills.

Think about this in terms of when you were in school. For example, what are good ways to learn math and social studies? Is there a difference in how one goes about learning these two different disciplines? Do the same learning techniques work equally well for all students? More generally, how can one tell if their learning processes are efficient and effective? Did you teachers help you to be good at self-assessment of your learning efficiency and effectiveness?

Research on effective learning indicates that metacognition and reflection are very helpful aids to learning. In metacognition, one thinks about their own learning and learning practices. In reflection, one reflects on and thinks about what one is learning, the meaning of what one is learning, the level of understanding that is being achieved, how the newly learned material fits in with what one already knows, the uses of the learning, and so on.

To be specific, ask yourself the extent to which you learned about metacognition and other reflective practices beginning in your earliest schooling. Research indicates that even preschool age children can learn to do metacognition and can learn to reflect on their problem-solving and other activities.

As a parent, you can help your children learn about metacognition and reflection, and help them to routinely practice these valuable skills.

## Study Skills

Study skills and learning to learn are closely related topics. Quite a bit of learning occurs naturally, with little conscious thought or effort. Children learn their initial oral communication skills without making conscious efforts to do metacognition and reflection.

However, as children begin to face the learning challenges provided in formal schooling, conscious learning efforts and studying become necessary. There is a huge amount of literature on study skills. My 8/15/06 Google search on the quoted expression “study skills” returned 15 million hits. I spent quite a bit of time browsing a number of the hits. Interestingly, the great majority of the hits address study skills for college students. That is, educators know that many students enter college with very poor study skills. Why? Because they have not learned and practiced effective study skills while they were in the precollege schools.

There is a lot that one might learn. See, for example, Kizlik (2006), which contains short summaries of many effective study skills. For example, here is a brief quote:

**Question**—ask questions for learning. The important things to learn are usually answers to questions. Questions should lead to emphasis on the what, why, how, when, who and where of study content. Ask yourself questions as you read or study. As you answer them, you will help to make sense of the material and remember it more easily because the process will make an impression on you. Those things that make impressions are more meaningful, and therefore more easily remembered. Don't be afraid to write your questions in the margins of textbooks, on lecture notes, or wherever it makes sense

There has been considerable research on environments that help or hinder in studying and learning. Such research provides insight into how one's brain can automatically, without conscious thought, filter out information that is not particularly relevant to what it thinks is important. We now understand why things such as food, shelter, and safety are such important considerations for learning. Schools and home need to be safe, supportive environments!

We understand why one needs to study in an environment that does not add significant additional challenges to one's filtering systems. Some students attempt to study textual material from a book while listening to music and talking to a friend on the phone. These three activities tend to interfere with each other.

A lot is known about different types of interference in learning. For example, interference arises when negative/positive feelings and attitudes hamper the acquisition of new knowledge. Cognitive interference is thinking and mental processing that interferes with the learning task. An example is provided by reading a math book and attempting to solve a math problem while talking to a friend about an upcoming party.

## Situated Learning

Learning is highly dependent on the situation (the environment) in which the learning is occurring. Brown, Collins, and Duguid (1989) is a seminal article on situated learning. Quoting from the introduction to this paper:

Recent investigations of learning, however, challenge this separating of what is learned from how it is learned and used. The activity in which knowledge is developed and deployed, it is now argued, is not separable from or ancillary to learning and cognition. Nor is it neutral. Rather, it is an integral part of what is learned. **Situations might be said to co-produce knowledge through activity. Learning and cognition, it is now possible to argue, are fundamentally situated.** [Bold added for emphasis.]

Situated learning is a learning theory focusing on the situation or environment in which a particular learning activity occurs. For example, suppose that you are walking down a jungle path and you hear a particular sound that your brain/mind does not immediately recognize. You “freeze,” carefully look around, and see a large snake.

Your brain/mind recalls that a friend of yours was seriously injured by a snake, and the description the friend gave seems to fit this snake. You immediately learn that the sound you have heard in this jungle trail environment is associated with a dangerous snake. Likely, this learning will last a lifetime. Moreover, the learning occurs very quickly—this is apt to be an example of one-trial learning.

Contrast this with sitting in a classroom that is in a large school located near your home. You live in a large city, and there are few or no dangerous snakes within miles of your home. You are viewing a video discussing dangerous snakes. You see and hear video of approximately the same scene as the jungle walker. However, the room you are in is hot and stuffy, you have just had lunch and you are sleepy, and the audio is turned up too high for your ears. What do you learn, and how long does this learning stay with you?

### **Transfer of Learning**

The low-road/high-road theory of learning has proven quite useful in designing curriculum and instruction (Perkins and Solomon, 1992). In low-road transfer, one learns some facts and procedures to automaticity, somewhat in a stimulus/response manner. When a particular stimulus (a particular situation) is presented, the prior learning is evoked and used. The human brain is very good at this type of learning.

The human brain functions by recognizing patterns and then acting upon these patterns. Low-road transfer is associated with a particular narrow situation, environment, or pattern. Consider the situation of students learning the single digit multiplication facts. This might be done via work sheets, flash cards, computer drill and practice, a game or competition, and so on. For most students, one-trial learning does not occur. Rather, a lot of drill and practice over an extended period, along with subsequent frequent use of the memorized facts, is necessary.

Rote memory is useful in problem solving, but it has severe limitations. The range of problems one encounters in everyday life is far too large to be handled just by rote memorization. Rote memorization is a slow process, and forgetting occurs unless the memorized facts and procedures are routinely used.

High-road transfer is based on learning some general-purpose strategies and how to apply these strategies in a reflective manner. It focuses on critical thinking and understanding. Here is an example. When faced by a complex problem, try the strategy of breaking the complex problem into a number of smaller, less complex problems. This is called the divide and conquer strategy. If the resulting problems are simple enough, you may well be able to solve each of them by drawing upon your repertoire of memorized facts and procedures.

It may also turn out that many of the smaller problems are easily solved by use of aids such as a calculator or a computer. That is, in some sense access to a calculator and a computer provide you with something akin to a large repertoire of memorized facts and procedures. The secondary school math curriculum is gradually changing to reflect this situation. Many courses at this level require use of scientific and/or graphing calculators. In the “good old days,” students

had to memorize an algorithm for calculating square roots. This algorithm has been dropped from the algebra curriculum.

Notice that divide and conquer strategy is applicable to problems in many different disciplines. Students are taught for high-road transfer by learning such strategies and by consciously and reflectively practicing them in a number of different disciplines. This is far different than rote memorization.

There are dozens of problem-solving strategies that are applicable over a wide range of disciplines and that build upon what one can memorize and the aids provided by calculators and computers. A very valuable strategy is to draw upon work that has been previously done by yourself and others. "Don't reinvent the wheel." A substantial list of such strategies is included in Moursund (June 2006a).

Research into student learning of problem solving indicates that most students have a relatively small repertoire of general-purpose problem-solving strategies. Most students are not being taught in a manner that facilitates high-road transfer of problem-solving and learning strategies that they encounter.

### **Working With Your Children and Their Schools**

There is a lot of accumulated knowledge about learning to learn and how to learn efficiently and effectively. Five key ideas are:

1. Teaching and learning environments should be designed to reduce interferences to learning. This is true both at school and at home.
2. It is important for each student to learn study skills that are efficient and effective, and that best fit with his or her needs and preferences.
3. Metacognition and reflection are two studying/learning strategies that are useful to all students.
4. The high-road/low-road theory of transfer of learning provides a good framework for designing effective teaching and learning activities.
5. Rote memorization is not a good substitute for learning with understanding. Calculators and computers provide an excellent substitution for some rote learning.

As you talk to your children about what they are doing in school, probe in these five areas. If these ideas are not being made explicitly clear in school, make sure that you explicitly teaching them to your child and that you and your child work together to frequently practice these ideas.

## Chapter 13: Computer-Assisted Learning and Distance Education

"The most dangerous experiment we can conduct with our children is to keep schooling the same at a time when every other aspect of our society is dramatically changing." (Chris Dede, written statement to the PCAST panel, 1997)

The science of teaching and learning (SoTL) provides us with considerable information about how to improve our educational system. However, translating theory into practice is quite difficult.

During the Industrial Age, machines were developed to aid in production. People and machines worked together to produce goods. As the production machinery got better, it took less people to produce an ever-increasing amount of goods.

At least since the time of Thomas Edison, people have been working to develop aids to translating the SoTL into practice. People now laugh at the following quote:

I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. (Thomas A. Edison, 1922.)

However, computers have made possible computer-assisted learning and Internet-based distance education that are both excellent vehicles for helping to translate SoTL into practice. This chapter provides a brief introduction to these two topics.

### Brief history of Distance Education

Distance education refers to the idea of a teaching and learning environment in which the teachers and students are not meeting face to face. Here is a tidbit of history on this subject quoted from McIsaac, & Gunawardena (1996).

Distance Education is not a new concept. In the late 1800s, at the University of Chicago, the first major correspondence program in the United States was established in which the teacher and learner were at different locations. Before that time, particularly in pre-industrial Europe, education had been available primarily to males in higher levels of society. The most effective form of instruction in those days was to bring students together in one place and one time to learn from one of the masters. That form of traditional educational remains the model today.

Actually, distance education has existed since the time of the first available of books. A book is an excellent vehicle for teaching and learning. The book author and the learner can be separated in terms of time and distance. Distance education became more formal when print materials were developed that contained detailed lessons and assignments to be completed and then mailed to a course instructor. The development of the telephone and radio added a new dimension, as the teacher and student could be located in different places, but could converse with each other. Distance education delivery via television, perhaps with the aid of a telephone connection to individual students or a room full of students, led to a significant increase in the use of distance education.

## **Asynchronous and Synchronous Distance Education**

From the very beginning of correspondence courses, course developers have put considerable effort into facilitating independent learning by students. In addition to the student having one or more course books, the student is provided with detailed lessons and assignments that can be completed without needing to interact with the instructor. The student must become an independent, self-sufficient learner to succeed in a correspondence course environment. (Of course, there is an exception to this. A student might be lucky enough to have a family member or friend willing to provide free or inexpensive tutoring—in essence, a one-on-one teacher.)

Correspondence courses are asynchronous—students work on a time schedule to fit their own needs, and students work independently of each other. This situation was changed when radio broadcasts and later TV broadcasts became a common component of distance learning. The student had to listen to the radio or view the TV when the broadcast was occurring. This was a type of synchronous instruction that was combined with asynchronous working on assignments and mailing them to the instructor.

Of course, as good and inexpensive VCRs became available, videotapes could be mailed to the student or the student could record a program for later viewing. Thus, this type of use of radio and TV delivery was easily converted to being asynchronous.

In formal school settings, it became relatively common to have student who were taking a TV-delivered course to meet in classrooms that had a telephone connection to the instructor. A few students could ask questions during the time of a lecture/demonstration. This is not unlike the “call in” radio and TV programs that are now quite common.

As email became available, asynchronous email distance education courses were developed. The email made it easier and quicker for students to interact with the instructor and each other.

More recently, Internet chat groups and Web-based two-way video have significantly changed distance education. While the postal services throughout the world are still used for some distance learning, the Internet has led to greatly expanded use of distance learning.

Finally, we come to the current situations. The Web can be used to hold ordinary telephone conversations and video conversations. Thus, the Web can be used to deliver synchronous distance learning. Of course, the Web can also be used to deliver asynchronous distance learning, with students having access to course multimedia materials at a time that fits their convenience.

The use of asynchronous and synchronous distance learning is steadily increasing. One can get a high school education, college education, and even do master's and doctorate degrees through accredited distance education programs.

Learning in a distance-learning environment is different than learning in traditional school classrooms, where one has daily face-to-face communication with fellow students and the teacher, and the class as a whole is following the exact same time schedule. Many people are now recommending that all students should take part of their precollege education via distance education, so that they will gain the knowledge and skills needed to learn in this environment. Skill in learning via distance education is now considered a valuable lifelong skill.

## **Feedback and Learning**

Feedback is essential to learning. You listen to a small child babbling, sort of making random sounds. You encourage this babbling by role modeling sounds such as ma ma ma, pa pa pa, or da

da da. When the babbler makes a sound that is somewhat similar to one you are encouraging, you provide feedback by your smile, enthusiasm, and hugs.

Feedback that is essential to learning can come from many different sources. For example, a child may be watching an instructional TV program especially designed to help very young children build vocabulary. The TV provides the instruction and role model. This child tries the words, strictly mentally or perhaps out loud. The child's mind and hearing provide feedback. The opportunity for self-provided feedback occurs repeatedly in a well-designed program.

A somewhat similar situation occurs as a child begins to attend school and is a member of a group of students learning together. A teacher asks the class a question, a number of students raise their hands volunteering to provide an answer, and one student provides an answer. However, all students have thought about whether they can provide an answer, and many have mentally rehearsed an answer. As the one student provides an answer, this information is used by the attentive listeners to check their own answers.

## **Benjamin Bloom**

Benjamin Bloom did excellent research in many areas of education. Thus, for example, all teachers learn about Bloom's Taxonomy, which provides a hierarchy of lower-order to high-order knowledge and skills. His research indicated that much of the testing in colleges and universities focused on lower-order knowledge and skills, and that this encouraged rote memorization instead of learning for understanding.

Bloom studied the effects of individual tutoring, either by professional tutors or via peer tutoring. Individual tutoring by a well-qualified tutor makes an average student (a "C" student) to perform at an "A" student level (Bloom, 1984). This is an astonishing finding. Of course, our educational system cannot afford to provide individual tutoring for every student. However, it does make considerable use of individual tutors or very small group tutoring/teaching to help alleviate various learning problems.

Research on individual tutoring helps us to understand the value of immediate feedback. When the tutor asks a question, the tutee is essentially forced to think about and then provide an answer, and the tutor provides immediate feedback. Keep in mind that when you work with your child in a one-on-one or very small group setting, you are providing a tremendous aid to learning that most students do not receive in school.

## **Computer-Assisted Learning**

Computer-assisted learning (CAL) can be thought of as a computerized version of an individual tutor. The computer system provides some instruction, perhaps using a combination of audio and video, animation, and print. The computer system then asks a question, which may be in the form of a problem to be solved or a task to be accomplished. The student provides a response, and the computer provides feedback to the student's response.

Much of the early CAL was mundane drill and practice—often a more expensive way of doing things that can be done very cheaply with flash cards. Even today, much CAI is merely drill and practice embedded in a game format, with lots of bells and whistles. This does little to improve essential higher-order thinking and problem solving skills.

Over the past 40 years, some CAL has gotten much better, and there has been considerable research on the effectiveness of computer-assisted learning. After researchers have conducted a

number of studies, it is common for a researcher to do a study of the studies. This is called a meta study. In the of CAL, so many meta studies were conducted that it became possible for a research to do a meta study of the meta studies. We know that, on average, students learn faster and better via CAL than they do via conventional classroom instruction.

In recent years, there has been considerable effort to improve the interface between the student and the CAL system. This is done by more careful design of the system and by making the CAL more intelligent. By use of artificial intelligence techniques, the CAL system can analyze response patterns, accept voice input, decide on appropriate feedback that will increase learning, and so on. Such systems are called Highly Interactive Intelligent Computer-Assisted Learning (HIICAL) systems.

HIICAL systems are expensive to develop. The development process requires a team with a wide variety of talents. Of course, the team needs experts in the content of the subject matter being taught. It needs experts in learning theory and how students learn. It needs multimedia experts who develop the multimedia materials used in instruction. It needs experts in developing AI interfaces. It needs programmers who put it all together. A yearlong course in one subject area might well cost \$5 million or more to develop and adequately test, and a million dollars or more a year to continue refinements of the course and keep it up to date.

Relatively few commercial companies have been willing to invest the funds to develop high quality HIICAL. The US Federal Government has funded a number of research and development projects. These are provided good “proof of concept” and some materials that are now available commercially. For more information, see AI Topics (n.d.). Such HIICAL is effective in implementing the research and development results coming from the science of teaching and learning (SoTL). In a variety of subject areas, there is good evidence that HIICAL is considerably more effective than the conventional school instruction.

### **Computer Simulations**

The Holodeck of Star Trek fame is a virtual reality computer simulation system. Over the past 50 years, considerable progress has occurred in the development of computer simulations designed for education and training purposed. An excellent early example is provided by the simulations that ran on the Distance Early Warning computer and radar systems designed to detect missiles targeted at the United States. Since users the operators of the DEW system did their work via computer, it was possible to build simulations that were indistinguishable from real world situations. A computer-generated set of radar sightings was displayed on the operators' screen, and they had to take appropriate action.

Now, such computer simulations are commonly used in training airplane pilots, astronauts, military tank crews, and in a host of other situations where conventional training is expensive and dangerous. There are many simulations that have been developed for use in K-12 and higher education. For example, there are dissection simulations that are often used in high school biology courses in place of having students do actual dissection of an animal. The Website <http://www.laserprofessor.com/DEFAULTcat.asp?catid=58> sells a variety of such simulations.

### **Working With Your Children and Their Schools**

A significant component of the future of education is embodied in HIICAL software that embodies what is known and being learned about the science of teaching and learning. This

HIICAL can be distributed by use of CD-ROMs and DVDs. However, increasingly the mode of delivery will be via the Web.

This vision of the future is one in which students throughout the country—indeed, throughout the world—will have access to multimedia HIICAL that covers the full range of subjects they might want to study, in their native languages or other languages of their choice, and at a grade level that fits their background and instructional needs. These aids to learning will gradually get better, as ICT systems continue to improve, as educational research continues to produce useful results, and as AI continues to make progress.

Of course, there is a huge gap between now and this future that I am forecasting. If you want to read more about my thoughts on the future roles of ICT in education, see my free book Moursund (2005a).

This vision of the future suggests considerable changes from the current organization and functioning of schools. The roles of teachers will change from being a “sage on the stage” to being a “guide on the side.” Teachers will no longer be a student’s main source of instruction and information. There will be a great increase in the individualization of programs of study. With sufficient leadership and funding from the Federal and State Governments, and from large private foundations, this change is inevitable.

Right now, our schools are designed to teach students to be heavily dependent on human teachers. You can help your children to learn to become more self sufficient, independent, lifelong learners. Help your students learn to learn both in today’s types of schools and in the types of learning environments they will face as adults.

# Part 4: Miscellaneous Other Topics

## Brief Summary of Part 4

Each aspect of a child's informal and formal education can be explored from an ICT point of view. One of my self-imposed guidelines in writing this book was to keep it short. Very few people are willing to wade through long, academically oriented books.

There is a lot known about adult education. Adults will learn what they want to learn. This has been well illustrated in formal adult-learning opportunities outside of traditional college and university courses. Adults will sign up for such courses and participate until they have learned what they wanted to learn. When their immediate learning goals have been met, they will stop attending and will use their time for things that they feel are more valuable. If a need arises later to learn more about a topic, they will enroll for the course again, or enroll for a slightly more advanced course that focuses specifically on their perceived needs.

The Chapters in Part 4 cover a variety of topics. The topics are relatively independent of each other. Most draw upon information presented in the first three Parts of the book.

Likely, one or more of these topics will interest you. The brief descriptions given below may whet your appetite or turn you away from various topics. For topics that interest you at this time, the brief chapter on the topic will give you an initial foundation for more learning. After that, you are on your own. You can seek out more information from sources, such as the Web, books, friends, and so on. You can look for informal and formal courses available in your community or via distance education.

**Chapter 14: Home Schooling and Schooling at Home.** Essentially all children receive a substantial part of their early education at home. Perhaps one percent of students in the United States receive a substantial part of their formal schooling via Home Schooling.

**Chapter 15: Children with Special Needs.** ICT provides powerful aids to meeting the needs of handicapped children.

**Chapter 16: Talented and Gifted Education.** ICT opens up additional opportunities for talented and gifted students.

**Chapter 17: ICT-Assisted Project-Based Learning.** Computers can play a significant role when students are engaged in lengthy, challenging projects.

**Chapter 18: Games and Education.** Games and puzzles, including computer-based games and puzzles, can be an important aid to education.

**Chapter 19: A Few Other Important Topics.** This chapter contains brief discussions of miscellaneous other topics that did not seem worthy of a full chapter at this time.

## Chapter 14: Home Schooling and Schooling at Home

“It takes a whole village to raise a child.” (African proverb)

"A great teacher makes hard things easy." (Ralph Waldo Emerson)

Each of us is a product of nature and nurture. We each have built-in strengths, weaknesses, and potentials that are inherited at conception and developed in the womb. Fetal development depends heavily on the proper nutrition, avoidance of a wide variety of harmful drugs and poisons, and general health of the mother. Thus, the physical and mental development of a child begins in the womb, home for the child's first nine months.

It is well known that a huge amount of learning occurs during a child's first few years of life, well before the age when they might begin to attend school. In that sense, all children are home schooled.

As children reach the age where they might begin attending a formal preschool, kindergarten, or primary school, their home schooling continues. Grade school formal schooling is only about six hours a day, for about half of the days in a year. This amounts to about one-eighth of a child's time. The home environment plays a major role in the education of grade school children.

Home schooling and schooling at home are related, but they are not the same thing. All parents are involved in schooling at home. Some make a still larger commitment of their time and energies to do home schooling.

### Traditional Home Schooling

A Google search of the expression *homeschool OR "home school" OR "home schooling"* returns more than 30 million of hits. There are a large number of local, regional, and national organizations that provide help to parents who decide to home school their children. However, home schooling requires a major commitment from the parents.

There are many reasons for deciding to home school one's children. The dominant one might be to help your child get a better education—one more aligned to your definition of a good education. You might want your child's education to include a strong emphasis on certain religious and cultural points of view that are not emphasized in traditional schools. Another good reason might be that you live far from a school, and you don't want your child to spend a large amount of time on school buses, commuting to and from school.

Here is a research-based educational reason. There is a lot of research supporting the academic value of one-on-one and small group tutoring. Home schooled children get much more one-on-one or very small group instruction and help per day than do students in a traditional school setting. Such individualized instruction and tutoring helps students learn better and faster than students in the standard-sized public school classes.

ICT is making very large contributions to home schooling. Perhaps the best example of this is the contributions of the Web. Via the Web, home-schooled children have access to a library that is far larger than the “hard copy” library found in any public or private school. That certainly levels the playing field in terms of access to information.

In home school environments where children have good access to the Web, they are apt to develop a high level of skill at accessing and using Web-based information. This develops a habit of mind—one in which one routinely does Web-based research as an aid to solving problems and accomplishing tasks. This habit of mind and Web research skills that one acquires will be of service throughout one's lifetime.

Another habit of mind that may well emerge is learning to depend upon oneself as a learner. Schools tend to inculcate students with the idea that the teacher will tell them what to do, when to do it, and how to do it. This can also happen in a home school environment. However, a home school environment provides far more flexibility to build a curriculum that fits the specific interests and needs of a child, and to give the child an appropriate (and steadily increasing, year by year) responsibility for his or her own education. In a home school environment with good access to the Web, a child can take a topic of personal interest and "run with it."

The growth in availability of computer-assisted learning and distance learning have also made a significant contribution to home schooling. In some sense, these two contributions bring highly qualified "virtual" teachers into the home. Parents facilitating home schooling can draw upon this resource, and many do.

Indeed, an interesting situation is beginning to occur. As school districts and states begin to make available more and more distance education courses, home-schooled students are taking advantage of these courses. Since these children are eligible to attend public schools, they can take the distance education courses and have the public school system pay for the courses.

Indeed, there are many situations in which students can sign up for a full load of these courses and receive a free computer to use at home. That is, some public schools, charter schools, and private schools (indeed, private, for-profit schools) are drawing on public funds to provide students with a distance education-based home school experience. Be aware, however, that in some cases, the arrangements require a significant commitment of time from the parents.

### **Possible Futures of Home Schooling**

I sometimes wonder where home school is heading. The changes going on in educational-related ICT are making it easier to home school one's children. That, by itself, might facilitate a gradual increase in the number of children who are being home schooled.

A second important factor might turn out to be telecommuting. A steadily increasing number of people work from home, making use of the world's steadily improving telecommunications system. Such telecommuting may make it easier for many families to decide to home school their children.

Public schools receive their money on the basis on the number of students enrolled and their attendance. Many public schools are seeing home-schooled students as an opportunity to increase their school income. The idea appears simple enough. The public school creates distance-learning courses to better serve a variety of their current students. After working through start up problems and expenses, the courses are cost effective. The school then realizes that the same courses can be made available to students who are currently being home schooled. A school can make a profit by increasing enrollment in its distance learning courses.

As more and better distance-learning courses are offered by a school district, the quality of service being provided is likely to improve. More "regular" public students will take some of their courses by distance learning. At the same time, more home-schooled students will take part

of their courses via distance learning through the public schools. The dividing line between home schooling and traditional public schools will diminish. Quoting from Hinrichs (2006):

Starting next July, the new Missouri virtual school will allow students in all 524 school districts to access classes via the Internet. Fuchs said the program will target students with access difficulties, particularly those in rural areas or smaller school districts that don't have certain electives and advanced placement classes available.

However, the program, part of the state Department of Elementary and Secondary Education, will be available to all students, including home-schoolers and private-school students.

...

To prepare and plan ahead for the program, Fuchs [head of the virtual school] has looked closely at similar programs in other states, visiting and talking with educators and school officials in Colorado, Georgia, Michigan and Iowa. Currently, there are 24 states with established virtual school programs, primarily in grades six through 12, Fuchs said.

Now, let me get a little more science fictionish. Childcare is one of the major roles played by traditional schools. Imagine a parent with a college education deciding to home school a child just ready to enter full day kindergarten. What would prevent this parent from starting a publicly-funded full day kindergarten school for a half dozen children? The next year this would become a publicly-funded first grade school. Two of the current answers are:

1. There are many legal and teacher credentialing reasons this cannot be done.
2. The typical college-educated person has not been educated and trained to be a teacher. The person lacks needed curriculum, instruction, assessment knowledge and skills, and access to instructional resources.

Both of these barriers are already being overcome by a variety of non-profit and for-profit educational institutions. Distance learning and computer-assisted learning (that includes or is supplemented by online testing) is an important component of this endeavor.

One of the missing ingredients right now is how to pay the parent. Why shouldn't a parent be paid for home schooling a child and/or a small group of children? The actual cost of providing high quality courses via computer-assisted learning and distance learning will continue to decrease. Already it is low enough so that the public funds used to support distance learning are often sufficient to provide free computers and instructional materials to the students and to generate a surplus (a profit) for the schools.

Another interesting variation on this futuristic scenario comes from the idea of providing students with vouchers that they can use to attend schools of their choice. Right now, the public education system in the United States is spending an average of over \$8,000 per student per year. Suppose that a parent could easily create a small private school (for profit or non-profit) and compete for students who have public-funded vouchers?

The ideas discussed in this section suggest to me that the future will bring us significant changes in home schooling and in the nature of how home schools, private schools, and public schools work together and in competition with each other to educate our children.

### **Working With Your Children and Their Schools**

The quotation at the beginning of this chapter is, "It takes a whole village to raise a child." This "whole village" includes home, religious institutions, community, and formal schools. It

includes the media, toys, tools and the infrastructure a child is growing up in. For each child, the combination of these learning opportunities constitutes the child's school.

Schooling at home requires a huge acceptance of responsibility for a child's education. Many parents continue this type of commitment and acceptance of responsibility even as their children move on into a traditional private, charter, or public school. However, many others seem to abdicate their responsibility. In essence, they expect the schools to take over all responsibility for their child's education once they children enter kindergarten or the first grade.

Remember, schooling at home (as distinguished from home schooling) goes on as long as your children are living with you. It is a serious mistake to assume that formal schools can successfully take full responsibility for the education of your children. Without your personal and concerted help, the education of your children will not be nearly as good as it could be.

We know that children learn in any environment, but that a "rich" physically and mentally challenging environment facilitates better physical and mental development. The term "rich" refers to having a wide variety of physical and mental opportunities, good feedback and encouragement, and a safe, loving, caring support system. It also refers to a child having decent food, clothing and shelter, medical care.

As a parent, you have many areas in which your level of expertise far exceeds that of your child. Through your individual efforts, you can help your child develop an increasing level of expertise in these areas. You can role model positive habits of physical and mental development.

Your total levels of knowledge and skills and your adult maturity and wisdom temper the ICT knowledge and skills you bring to this task. You have had a tremendous amount more life experience than your child. It may well be that your nine year old child seems to know more about computers than you. However, your nine-year-old child knows relatively little about roles of computers in finding information to help solve problems. Your nine-year-old child lacks adult maturity in protecting him or her self from the threats of the Web, and other communication systems.

## Chapter 15: Children with Special Needs

I am quite often asked: How do you feel about having ALS? The answer is, not a lot. I try to lead as normal a life as possible, and not think about my condition, or regret the things it prevents me from doing, which are not that many. (Steven Hawking)

Many people have a highly over simplified and incorrect mental model of students falling into one of three relatively distinct categories: 1) disabled; 2) normal; and 3) talented and gifted. This model does a major disservice for students with exceptionalities.

A person's physical body and brain are very complex. Even identical twins, raised as nearly alike as possible, have significant mental and physical differences. When a person's mental or physical difference from the norms is sizable, the person is said to have an exceptionality. Steven Hawking (see the quote given above) is a brilliant physicist who has ALS (often called Lou Gerhig's disease). He makes use of an electrically powered wheelchair and a computerized voice synthesis system. He has multiple exceptionalities.

This chapter looks at some roles of ICT for students with handicapping conditions—that is, children with exceptionalities that impede functioning at the norms people who do not have these challenges. The next chapter looks at roles of ICT for talented and gifted students. Remember, many children have multiple exceptionalities and fall into both categories.

### Individuals with Disabilities Act

Many children face extraordinary physical and mental challenges. The 1975 federal law, PL 94-142 helped to define various physical and mental challenging conditions and requirements that schools must meet in serving these students.

During the past 30 years, the law has been modified somewhat, and it has been clarified by the results of a number of legal cases. The most recent amendments were passed by Congress in December 2004, and the law is now called the Individuals with Disabilities Education Act (IDEA).

During this same period of time, ICT has changed greatly. There are now many powerful assistive devices that did not exist when PL 94-142 was first enacted. Quite a few of these assistive devices are also of use to students who do not meet the strict definitions of the December 2004 IDEA.

### A Dyslexia Example

In terms of learning to read and write, quite a few students face the challenge of dyslexia. The brains of dyslexic children are “wired” somewhat differently than those of non-dyslexic children, in a way that makes learning to read and to spell especially difficult. Such children may also have significant problems with oral language and with math calculations.

Sally Shaywitz is one of the world's leading experts in dyslexia (SchwabLearning.org, 2003). Her research, as well as the research of many others, suggests that between 5% and 20 % of children are dyslexic.

It has long been known that a word processor with a spelling checker is a powerful aid to dyslexic children. In 1999, a group of parents in Oregon filed a federal lawsuit against the State Board of Education claiming Oregon's standardized tests violate the Americans with Disabilities Act and hurt Oregon children with learning disabilities. They were successful in this suit.

Under the settlement, students with dyslexia are allowed to use computers or word processors with a spell-check feature on state tests. The court decision also provides certain other types of relief. For example, some students may be allowed to use calculators. In some cases, the tests will be read aloud to a child by a helper, and some children will be allowed to recite their answers into a machine.

This legal case is apt to be repeated in many other states. Indeed, the evidence to support providing dyslexic students with a computer, word processor, and spell checker is so strong that this is becoming a common part of IEPs of dyslexic students throughout the country.

Research into dyslexia and ways to help dyslexic children has been greatly helped by the steady improvement in brain imaging equipment in brain science in recent years. Highly interactive computer-assisted learning software (HIICAL) has been developed to help such children. The research has begun to show that an intensive intervention—especially with children in kindergarten and the very early grades—can actually cause “rewiring” of the brain in a manner that significantly helps in overcoming the challenges of dyslexia.

### **A Personal Example**

Although I have been quite successful in my career as a professor, researcher, and writer, I have at a variety of significant handicapping conditions, including poor eyesight and poor manual dexterity. When I took the State of Oregon vocational employment tests near the end of high school, I learned that I had quite poor spatial abilities. More recently, I learned that I have face blindness (prosopagnosia).

Eyeglass technology, and more recently lens implants needed because of cataracts, have helped me overcome my visual problems. I chose a career in which good manual dexterity is not a requirement for success. My spatial problems can be helped a lot by use of a GPS, and the next car I buy will likely contain this equipment.

To a certain extent, I have developed coping skills to deal with my frequent problem of encountering people that I know, but do not recognize. Perhaps some time in the future I will have wearable face recognition hardware and software connected into my eyeglasses in a manner that projects the name of a person I am looking at onto my retina. Indeed, I might well also be wearing a GPS that ties in with my eyeglasses and helps me to go where I want to go.

### **Dyscalculia and Other Math Challenges**

Probably you know some people who say, “I can’t do math.” Some of these people have had poor math education and could be helped by better teaching. Others may have dyscalculia, a difficulty in learning certain aspects of math (Stanescu-Cosson et al., 2000; Pearson, 2003). Quoting from Geary (1999):

Research on learning disabilities in mathematics (MD) has also progressed over the past ten years, but more slowly than the study of reading disabilities. One of the difficulties in studying children with MD is the complexity of the field of mathematics. In theory, MD could result from difficulties in the skills that comprise one or many of the domains of mathematics, such as arithmetic, algebra, or geometry. Moreover, each of these domains is very complex, in that each

has many subdomains and a learning disability can result from difficulties in understanding or learning basic skills in one or several of these subdomains.

Perhaps 5-7 percent of students have some form of dyscalculia. Early identification of dyscalculia can make a significant contribution to helping students deal with this learning disability. Symptoms of dyscalculia include (Dyscalculia, n.d.):

- Difficulty with numbers;
- Poor understanding of the signs +, -, / and x, or may confuse these mathematical symbols;
- Difficulty with addition, subtraction, multiplication and division or may find it difficult to understand the words “plus,” “add,” “add-together”;
- May reverse or transpose numbers for example 63 for 36, or 785 for 875;
- Difficulty with times tables;
- Poor mental arithmetic skills;
- Difficulty telling the time and following directions.

It is easy to see how use of a calculator, computer, digital watch, and other electronic aids can be of help to a person with dyscalculia.

To do a precise diagnosis that a student has dyscalculia requires considerable knowledge and skill. However, an elementary teacher or a parent can easily study the bulleted list given above and do a preliminary screening of students who seem to be having considerable difficulty in learning math. In addition, students identified as dyslexic should also be carefully screened for dyscalculia.

## **Attention**

Attention is a large and important component of the discipline of neuroscience. A human's five senses bring in an overwhelming amount of data. The brain, at a conscious and subconscious level, pays attention to some of this data; however, it filters out and ignores most of this data.

Some people are much better at focusing their attention and filtering out unwanted data than others. Attention deficit disorder affects perhaps three to five percent of children. (And, of course, adults can also be ADD.)

ADD presents a challenge both to teachers and to students. In a schoolroom class, a student's brain is processing input from five senses, and it is thinking about lots of other things. For example, it may be sensing that he or she is hungry, bored, will have a lot of fun later in the day, would rather be listening to some good music, is worried about a recent interaction with a friend, and so on. A teacher needs to teach in a manner that catches and holds student attention, and the student needs to learn to focus his or her attention on the current learning task.

An IEP for ADHD often includes providing students with computer access and making use of a variety of other ICT, such as HIICAL and voice input and output systems. There has been some success in developing software that is designed to train the brain to better deal with ADHD, although the supportive research is not very strong. Quoting from an article by Susan Jenks (2006):

A generation raised on video games is inspiring researchers' efforts to unlock the mysteries of a puzzling learning disorder that afflicts millions of school-age children and even some adults.

Whether speeding down a virtual street in Sony's Gran Turismo or slaying Spyro the Dragon, researchers hope games such as these will improve the lives of those with attention-deficit hyperactivity disorder, commonly known as ADHD, or cognitive-processing difficulties.

### **Severe Speech Delay in Children with Normal Hearing**

Perhaps two to four percent of children are significantly delayed in learning to speak because their brains process phonemes much slower than those of average children. These children do okay on a standard hearing test, because they can hear tones of various frequencies. Their problem is that when they hear a sequence of words, their brains process the syllables of the words very slowly. Thus, more words pour in before the first words can be processed. The result is that such children are very slow in learning to speak, even with multi year interventions of well-qualified speech therapists.

In recent years, computer software has been developed to treat this problem. An interactive game has been developed that can speak the syllables of words very slowly. As a child plays the game and learns to respond correctly to slowly spoken words, the software then speed up the presentation. Over a period of sessions of an hour or two per day, for six weeks or so, the child's phoneme processors tend to be rewired so they run at about the speed of people not having this speech delay problem. Scientific Learning Corporation has pioneered this research and treatment.

### **Using Thought as a Computer Input Device**

Recent years have seen significant progress building hardware and software that can read brain activity and use it to control a computer. Quoting from BBC News (2005):

Matthew Nagle, 25, was left paralyzed from the neck down and confined to a wheelchair after a knife attack in 2001. The pioneering surgery at New England Sinai Hospital, Massachusetts, last summer means he can now control everyday objects by thought alone. ...

He can think his TV on and off, change channels and alter the volume thanks to the technology and software linked to devices in his home. Mr Nagle's device, called BrainGate, consists of nearly 100 hair-thin electrodes implanted a millimetre deep into part of the motor cortex of his brain that controls movement. Wires feed the information from the electrodes into a computer which analyses the brain signals.

### **Working With Your Children and Their Schools**

Many—perhaps all—people have learning disabilities and other handicapping conditions. If the conditions are sufficiently narrow, they are apt to go undiscovered and are handled by the person making accommodations.

However, many of these handicapping conditions are sufficiently challenging so that it is highly desirable that they be recognized and diagnosed relatively early in a person's life. Then, education, assistive devices, and other accommodations, can help a great deal. Research suggests the desirability of helping children to understand the challenges they face and to have them play an active role in dealing with the challenges.

## Chapter 16: Talented and Gifted Education

"Ability will never catch up with the demand for it." (Confucius)

"An intellectual is someone whose mind watches itself." (Albert Camus; French novelist, essayist and playwright, who received the 1957 Nobel Prize for literature.)

The previous chapter discussed exceptionalities, and it pointed out that many people have both handicapping conditions and special abilities. This chapter explores some roles of ICT in the education of children with special abilities. These children may be identified as talented and gifted (TAG) and receive special attention in their schooling. However, many schools are slow to do such assessment in the K-2 grades.

The multiple intelligences work of Howard Gardner and others suggests that a person may have special abilities in some areas and not in others. You probably have heard the expression, "Play to your strengths." Many people find it advantageous to commit extra time and effort in developing islands of expertise within their areas of high natural ability.

ICT can play a significant role in this. For example, suppose that a person has some natural ability and intrinsic motivation in art or music. Substantial education in one of these areas, accompanied with thorough integration of ICT tools within the area, might well lead to a successful career or avocation.

### Definitions

While the two terms *talented* and *gifted* do not have exactly the same meaning, most people use them interchangeably. However, sometimes it is useful to differentiate between the two terms. Giftedness or natural ability may be defined by a score on a general IQ test, while talent may be defined by knowledge, skills, and performance in a specific discipline area such as math, music, or writing. From this point of view, natural abilities are gifts, while talents are what one develops from his or her natural abilities and gifts.

There are many different definitions of TAG. The literature often refers to the following statement by former U. S. Commissioner of Education Sidney P. Marland contained in his August 1971 report to the U.S. Congress.

Gifted and talented children are those identified by professionally qualified persons who by virtue of outstanding abilities are capable of high performance. These are children who require differentiated educational programs and/or services beyond those normally provided by the regular school program in order to realize their contribution to self and society (Marland, 1971).

It is quite common to use IQ tests to help identify TAG students. The following quote from the ERIC Clearinghouse on Disabilities and Gifted Education defines three levels of giftedness in terms of scores on the Weschler Intelligence Scale for Children.

Highly and profoundly gifted students are children whose needs are so far beyond "typical" gifted that they require extraordinary resources. When tested with a Weschler Intelligence Scale for Children (WISC), their scores range from 145 to 159 for highly gifted and above 160 for profoundly gifted. In those ranges, these children are as different in intellectual abilities from gifted children (usually 130 to 144) as gifted are from a typical regular education population. **IQ**

**scores do not tell the whole story; however, they are a useful indicator of individual differences, particularly when used to inform instruction** (ERIC, Profoundly Gifted, n.d.). [Bold added for emphasis.]

## Identification

The following is quoted from an ERIC Digest article (Coleman, 2003):

The best identification practices rely on multiple criteria to look for students with gifts and talents. Multiple criteria involve:

- **multiple types of information** (e.g., indicators of student's cognitive abilities, academic achievement, performance in a variety of settings, interests, creativity, motivation; and learning characteristics/behaviors);
- **multiple sources of information** (e.g., test scores, school grades, and comments by classroom teachers, specialty area teachers, counselors, parents, peers, and the students themselves); and
- **multiple time periods** to ensure that students are not missed by "one shot" identification procedures that often take place at the end of second or third grade. [Bold added for emphasis.]

## TAG at State and National Levels

The Web contains a huge number of sites that discuss TAG education. Each state has one or more TAG Associations and most of these have Websites. The states in the U.S. vary considerably in the emphasis and funding provided for TAG education. Thus, some provide essentially no special funding, while others may provide a substantial amount for this purpose.

At a national level, TAG is considered important, but it receives relatively little funding and is not mandated by law. However, the U.S. Federal Government does support the National Research Center on the Gifted and Talented (NRC/GT, n.d.). Quoting from its Website:

The work of The National Research Center on the Gifted and Talented (NRC/GT) is guided by emerging research about the broadened conception of human potential and the need to develop "high-end learning" opportunities for all of America's students. Programs and services designed to challenge the highest levels of learning and creativity; to promote high expectations, rigorous standards, and greater engagement with subject matter should be an integral part of every school's overall program. ... Accordingly, our orientation and related research has been to apply the strategies of high-end learning to total school improvement and to focus our research on developing gifts and talents in young people based on a broad array of both traditional and emerging indicators of potential for high performance. (<http://www.gifted.uconn.edu/nrcgt.html>)

## Joseph Renzulli

The NRC/TG is directed by Dr. Joseph Renzulli, a world-class TAG educator. He has developed an approach to TAG education designed to serve the full range of TAG and non-TAG students in a school. He calls it the *Total Talent Portfolio* (TTP) approach. You can use this approach with your children, or your children's schools can use it to improve education.

The basic idea is that each student has some gifts that have been developed into talents or could be developed into talents. Each child can develop islands of expertise. The starting point is to develop a total TTP for each student. This can be done by a combination of effort on the part of parents, teachers, and the student. Details on this process are available in my free book on roles of computers in TAG education (Moursund, 2006c).

Here is a brief summary.

1. Identify a student's preferences in four areas:

- a. Instructional style preferences. There are many different ways to teach, such as lecture, small group, project-based, and so on. Each student should come to understand the modes or styles of instruction that best fit their needs in the various subject areas they are studying.
  - b. Learning environment preferences. Students vary considerably in terms of the sound, light, clutter, indoors or outdoors, windows, time of day, food availability, and so on they sense makes an ideal learning space.
  - c. Thinking style preferences. This might make use of the three categories developed by Robert Sternberg: Analytic (school smarts); Creative/Inventive; and Practical (street smarts). Another approach, also drawing on the work of Sternberg, is to make use of the three categories: *Legislative* (creating, planning, imagining, and formulating); *Executive* (implementing and doing); and *Judicial* (judging, evaluating, and comparing). (Sternberg, n.d.)
  - d. Ways of demonstrating learning. Examples of possible modes include written, oral, using manipulatives (such as math manipulatives), whole class or small group discussions, artwork, dramatization, graphic (such as video), service work, and work for pay.
2. Identify a student's areas of relative strength and areas of relative weakness. The idea is to look for both for potential (aptitude, IQ) and for actual knowledge, skills, and usage. The student, teachers, parents, and others might identify some actual strengths and weaknesses of a student. Both strengths and weaknesses can be measured compared to oneself as a whole, as compared to one's peers or some particular group, as compared to some set of norms or standards, and so on.
  3. Identify a student's interest areas. It is highly desirable that at least some parts of a student's education focus on areas that really interest the student. In addition, instruction and learning in an area that does not really interest a student can often be enhanced by relating the area to those that do interest a student. For example, a student might not be interested in the history of the Civil War in the US. However, the student might well be interested in music, and thus the music of the Civil War.

This three-part analysis can be done holistically, and it can also be done focusing on a specific area such as ICT. When a student is quite young, it is parents and teachers who can make the best use of this Total Talent Portfolio information. As a child gains increasing levels of cognitive skills and maturity, the child can begin to take increasing responsibility for his or her own education. As a parent, you can help guide this process. Help your child to gradually be less dependent on you and teachers, and more dependent upon him or her self.

### **TAG Students Learn Faster and Better**

With appropriate encouragement and educational support, TAG students learn faster and better than average students in their areas of giftedness. There are two standard approaches to addressing the faster and better. These are called *enrichment* and *acceleration*.

In enrichment, a student studies the topic of a school lesson in greater breadth and/or depth. This idea fits in well with ICT. A TAG student may well be able to master both the traditional content and also learn roles of ICT in representing and solving the problems being studied in that lesson. Project-based learning helps to facilitate and encourage such activities.

In acceleration, a student skips one or more grades in one or more subject areas. Making use of distance learning courses or higher level courses in his or her school, a high ability math student might well move through the traditional years of precollege math courses twice as fast as an average student. For more information on this topic, see <http://www.jhu.edu/cty/>. A student who is TAG in the full range of academic courses may well graduate from high school and enter college a number of years sooner than his or her peers.

Often the two approaches are combined. A student may well be taking the regular physical education and music education instruction in school, but also be on a swim team and be taking private music lessons outside of school.

There is considerable evidence that TAG students tend to be bored by school if they are not given special attention. Indeed, the drop out rate for TAG students is surprisingly high. Acceleration has proven quite successful for such students.

### **Working With Your Children and Their Schools**

If you have children who are gifted in some particular areas, then you should consider helping them develop these gifts into islands of expertise. Earlier parts of this book have pointed out how many thousands of hours of hard work—supported by parents, teachers, and coaches—it takes to “be all you can be” within a particular area.

As a parent, you are well positioned to begin identifying your child’s strengths, weaknesses, and areas of interest even before the start of formal schooling. You can begin to develop a Total Talent Portfolio for your child. You can begin to provide help and encouragement that will help your child to develop cognitively and physically.

The Total Talent Portfolio can be the basis for ongoing conversations with your child. For example, when talking to your child about “what did you learn today,” the TTP provides many possible topics that might be explored.

Regardless of the levels and/or areas of you child’s TAGness, make sure that various components of ICT are scattered throughout the TTP. For example, how well does your child learn in a computer-assisted learning environment? What can you do to overcome weaknesses and encourage use of strengths in this learning modality? Similar statements hold for distance education. You want to make sure that your children learn to learn in computer-assisted learning and distance learning environments. These learning skills will be of lifelong value.

## Chapter 17: ICT-Assisted Project-Based Learning

"An individual understands a concept, skill, theory, or domain of knowledge to the extent that he or she can apply it appropriately in a new situation." (Howard Gardner.)

Most schools make use of Project-Based Learning (PBL). In PBL, students work individually, in small teams, and in large groups—such as whole class or whole school—over a significant length of time. Projects result in products, performances, and presentation. (See my Website <http://darkwing.uoregon.edu/~moursund/PBL/>.)

ICT has added a powerful new dimension to PBL. It allows students to do research on the topics they want to explore for their projects. It allows the development of multimedia products, performances, and presentations. Teams of students from far apart places can work together.

In small team projects, students learn to do peer assessment, provide constructive feedback to each other, learn from their teammates and help their teammates learn, and learn to work together on tasks that are too large for one person to complete in the time available. These are all quite valuable lifelong skills.

### Project-Based Learning Versus Problem-Based Learning

Project-Based Learning and Problem-Based Learning have similar sounding names. However, there are relatively different approaches to education.

In Problem-Based learning, all students are given the same problem situation or specific problem. In a business course, the problem situation might be a careful description of a company that is in financial trouble. In medicine, it might be a patient coming into an emergency room. Problem-Based Learning can be thought of as a type of simulation in which a student is immersed in a specific problem environment and is expected to clearly define and solve or help solve the problem. The problems presented to students are quite similar to the real world problems they will face on the job after completing their training and education.

Project-Based Learning is far more open-ended and is designed to give students considerable freedom to make decisions about what they will learn and how they will demonstrate their learning. For example, suppose that the regular school curriculum at a particular grade level calls for students to spend three weeks studying the U.S. Civil War that pitted the South against the North. The teacher and students might work together to decide on interesting and important aspects of this war. For example, medicine was an important issue, as many people died from disease or from wounds that are now easily and successfully treated. The use of slave labor in agriculture and other businesses was a major issue. Music, art, food, clothing, literacy rates, politics, great soldiers, contributions of women, newspapers and other publications, and all kinds of other topics might be studied as part of studying the Civil War.

The students and teacher working together might decide on a half dozen specific topics that they want to stress. Then they work together to divide the class into teams of about four students each. Some teachers do this based on the Multiple Intelligence categories developed by Howard

Gardner. They want each team to have a number of different ability areas represented. However, it is also possible to do ability grouping, or a variety of other approaches.

Each team is to select four of the topics, with each person on a team responsible for one specific topic. Each team decides whether it wants to develop a performance (perhaps a short skit or a musical performance), a presentation (perhaps a multimedia presentation), or a product (perhaps a short film or a short booklet). Each team member is responsible for helping others on the team learn about the specifics of his or her topic. The team members must work together to integrate their individual efforts and to produce a performance, presentation, or product.

The teacher assesses each student on the basis of their individual work and their contribution to the team. Assessment is usually done making use of a detailed rubric that is developed by the teacher and students working together. A key idea in use of such rubrics is that students fully understand the assessment criteria and learn to self-assess.

Typically, a PBL lesson does not include a final exam. This is because various students will be studying and learning quite different topics. However, it may be that a PBL lesson will include reading material that all students are responsible for. In that case, traditional testing over that material is appropriate.

### **An ICT-Assisted PBL Lesson has Multiple Goals**

The teacher developing an ICT Assisted PBL lesson has a number of learning goals in mind. Figure 17.1 contains an example of some possible goals.

<b>Goals. Students will learn:</b>	<b>Points</b>
1. An appreciable amount of subject matter content in the discipline or disciplines of the project.	
2. ICT as integral part of the subject matter content listed in (1) above.	
3. To carry out interdisciplinary tasks and to make use of basic ICT tools in this endeavor.	
4. How to budget resources (including time) in doing a project, and to self-assess one's progress in doing a project.	
5. To work as a cooperative, collaborative member of a team.	
6. To be a project proposer, a problem solver, and a "creative, higher-order" thinker, working in a learner-centered environment.	
7. To do peer assessment and gain skill in providing constructive feedback to one's peers.	
8. To transfer their learning over time, distance, and environments.	
9. To learn to be an independent learner and to help others learn all of the above.	
10. (Other, please specify.)	
Total Points →	100

Figure 17.1. Multiple goals in an ICT-Assisted PBL lesson.

Remember, ICT is an important part of the content of each discipline that students study in school. Item (2) in the list stresses learning aspects of ICT that are quite specific to the discipline being studied in item (1).

Most real world problems are interdisciplinary. That is why item (3) is in the list. Item (4) in the list because many people are quite poor at doing the planning needed in a lengthy project.

It is important to realize that the typical state and national assessments do not cover many of the goals listed in Figure 17.1. In talking about goals of education, people often refer back to the 1991 report of the US Secretary of Labor's Commission on Achieving Necessary Skills (Scans,

1991). This report identified five major competencies that people need for future employment. Each of the five categories has a number of subcategories. Just a few of them are listed below.

**Resources:** Identifies, organizes, plans, and allocates resources

- Time & Selects goal-relevant activities, ranks them, allocates time, and prepares and follows schedules

**Interpersonal:** Works with others

- Works with Diversity & works well with men and women from diverse backgrounds

**Information:** Acquires and uses information

- Uses Computers to Process Information

**Systems:** Understands complex inter-relationships

- Understands Systems & knows how social, organizational, and technological systems work and operates effectively with them

**Technology:** Works with a variety of technologies

- Selects Technology & chooses procedures, tools or equipment including computers and related technologies
- Applies Technology to Task & Understands overall intent and proper procedures for setup and operation of equipment

I am impressed by the foresight of this 1991 document. Even now, 15 years later, it provides excellent advice. Compare this list with the narrowness to the current implementations of No Child Left Behind.

### **Assessment Using Rubrics**

A project is designed to produce a product, performance, or presentation. As one works in this production process, there is an opportunity to receive feedback from oneself and others. This feedback can be used to improve the quality of the product, performance, or presentation. As in writing, a key to high quality work in PBL is “revise, revise, revise.”

You are familiar with the use of tests in school. By and large, traditional tests are not an appropriate tool for assessing the work a student has done in a PBL lesson. There are a variety of reasons for this. Foremost is that in PBL, each student may be doing and learning something different. Even if all students are doing a project on one specific topic, each student may be using different sources of information and learning different things.

A second challenge to assessment in PBL is that students often work in teams. The various members of a team may make significantly different contributions to the product, presentation, or performance.

Assessment in PBL typically makes use of rubric that are clearly understandable to the students, the teacher, and others who might be involved in the assessment. A rubric provides detailed criteria that are highly relevant to the type of product, performance, or presentation being developed. That is, the goal is for the assessment to be authentic.

Suppose, for example, that in a particular PBL lesson each student is to do research on a certain aspect of the U.S. Civil War, write a newspaper article of the type that might have appeared in a newspaper at the time of the war, and do an oral presentation (making use of presentation software) to the whole class. Then two rubrics are needed—one for the quality of

the writing, and one for the quality of the oral presentation. Each of these rubrics needs to include components that help measure the quality of the research that was done.

Each of the rubrics may have one or more distinct sub-rubrics. For example, the presentation needs to be evaluated both on the quality of the presentation software materials that were developed, and on the quality of the actual presentation.

Figure 17.2 provides a framework that I often use in developing a more specific rubric for a particular PBL lesson.

Level	Brief Description
Level 1: Emergent Points: 0-2	Student displays little, if any, of the rudimentary knowledge and skills that are expected. (We also use this level, and a score of 0, if the assignment is not turned in.)
Level 2: Limited Points: 3-4	Student displays rudimentary knowledge and skills, but these are not at a level appropriate to a graduate student.
Level 3: Developing Points: 4-5	Student displays a minimally adequate level of the expected knowledge and skills.
Level 4: Capable Points: 7-8	Student displays a functional, good level of the expected knowledge and skills.
Level 5: Strong Points: 9-10	Student displays a high level of the expected knowledge and skills.

Figure 17.2. General framework for five-level rubric. It lacks the details needed to make it specific to a particular assignment.

## Working With Your Children and Their Schools

You want your children to be well prepared for the types of jobs they are apt to face as adults. They will be living in and working in a nation with considerable diversity, and this diversity will be increasing. They will be competing with workers from other countries—think of telecommuting, out sourcing, and off shoring. They will be competing with increasing factory automation and with workers well prepared in making use of ICT aids to their brains.

At the same time, they will be human beings, interacting with other human at work and at play. They will need a wide range of social skills. They will need the human values and skills that computer systems do not have.

ICT-Assisted PBL helps to create teaching and learning environments that are well attuned to preparing students to meet the future demands discussed briefly above and in the SCANS report. Quite likely your child will be engaged in PBL from time to time. If this does not seem to be occurring, ask the teachers about this.

If your child is engaged in PBL, talk to your child about the various goals listed in Figure 17.1 Look for signs of explicit teaching and emphasis on the various possible goals. Remember, it is not easy to learn to budget one's time when doing an extensive project. It is not easy to learn to work with others. It is not easy to learn to make effective use of ICT as an aid to solving problems and accomplishing tasks.

## Chapter 18: Games and Education

Men occasionally stumble over the truth, but most of them pick themselves up and hurry off as if nothing ever happened. (Sir Winston Churchill)

A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty. (Winston Churchill)

This chapter is about some roles of games in informal and formal education. Many people see Games-in-Education as an opportunity to help improve our educational system.

For many people, games are intrinsically motivating. Educational research tells us that intrinsic motivation contributes substantially to learning. From an educational point of view, the issues are what does one learn through playing games, how does this learning relate to helping students achieve agreed upon goals of education, and what roles should teachers and other mentors play? For a free book on these uses of games in educations, see Moursund (2006a).

### Games-in-Education as a Discipline of Study

The field of education can be divided into many different disciplines. Similarly, the field of games and gaming can be divided into many different disciplines. This chapter explores some of the overlap between education and games. As illustrated in Figure 18.1, the overlap can be thought of as a discipline called Games-in-Education.



Figure 18.1. Venn diagram illustrating Games-in-Education.

The Games-in Education discipline received increased legitimacy in October of 2003 when the Massachusetts Institute of Technology announced an initiative to study educational roles of computer games (Games-to-Teach Project, n.d.). Many colleges and universities now offer undergraduate and graduate degree programs in the discipline of Games-in-Education.

There has been extensive research on how the human brain gains increased expertise in game playing. Phillip Ross (2006) provides an excellent summary of this work. Quoting from the article:

How much can be credited to innate talent and how much to intensive training? Psychologists have sought answers in studies of chess masters. The collected results of a century of such research have led to new theories explaining how the mind organizes and retrieves information. What is more, this research may have important implications for educators. Perhaps the same techniques used by chess players to hone their skills could be applied in the classroom to teach reading, writing, and arithmetic.

## Types of Games

The term *games* includes Crossword puzzles, brain-teaser puzzles, card games, board games, massively multiplayer online games, and so on.

Many games are playable both in a computer mode and a non-computer mode. For example, many solitaire card games and Poker games require only a standard 52-card deck. Many of these can also be played on a handheld electronic game device, a game machine, or on a computer.

Here is a definition:

Garris et al. (2002) define game play as “voluntary, nonproductive, and separate from the real world” (p.459). On the other hand, Jones (1999) points out that **for some people, computer and video games are real and sometimes, they are more engaging than reality**. Computer games can be categorized as adventure games, simulation games, competition games, cooperation games, programming games, puzzle games, and business management games [Bold added for emphasis.]

Notice the bolded statement in the above definition. For many people, games are attention grabbing and attention holding. They are intrinsically motivating, and they may be addictive. This is an important idea to keep in mind as you explore possible roles of Games-in-Education.

Here is another quite useful way to think about games (Costikyan1994):

Games provide a set of rules; but the players use them to create their own consequences. It's something like the music of John Cage: he wrote themes about which the musicians were expected to improvise. Games are like that; the designer provides the theme, the players the music.

A game is a form of art in which participants, termed players, make decisions in order to manage resources through game tokens in the pursuit of a goal.

## Game Worlds Versus non Game Worlds

The quoted material from Greg Costikyan gets to the very heart of possible values of games in education. Games have many of the characteristics of the non-game world. Put a different way, much of what we do in our everyday lives can be considered game-like. Quoting Shakespeare from *As You Like It*):

All the world's a stage,  
And all the men and women merely players:  
They have their exits and their entrances;  
And one man in his time plays many parts,

Thus, many people view various aspects of their jobs as being “playing the game.” Others view various aspects of going to school as playing a game.

Many games can be considered simulations of various aspects of the non-game world. For example, consider Chess, Monopoly, The Sims, and airplane pilot trainers. In each case, the players are engaged in a type of simulation. Some of the learning that occurs in the simulation transfers to situations outside of the simulation. The airplane flying simulations are so good that they are a routine component of training and retraining pilots.

The value of a computer game in education tends to depend mainly on two things:

1. How closely the game relates to the learning that one wants to occur. Pilot simulators are highly educational because the simulations are very like the real thing. Transfer of learning from one to the other is easy.
2. The extent to which learners are facilitated by teachers, coaches, parents, and others in making a transfer from the game to the real thing. As a parent, for example, you might well play alongside your children and from time to time emphasize and make explicit what is going on in the game and how this relates to situations outside the game.

### **Solving Problems and Making Decisions**

A game provides a limited and safe environment in which one can learn the rules, and then learn to solve the problems, accomplish the tasks, and make the decisions involved in playing the game. With study, practice, and help from others, one can gain an increasing level of expertise in a game. Notice the emphasis on solving problems, accomplishing tasks, and making decisions.

That description is quite similar to a description of school and schooling. One of the advantages of games over traditional schooling is that a player can readily see progress occurring in achieving a higher level of expertise. For example, in a few hours a student can go from not knowing anything about the game of chess to playing the game—making legal moves, and recording and talking about the results of playing a game. In a few more hours, a person can see that their level of play has increased substantially.

Interestingly, research into schooling in various topics such as math indicates the value of students (and their parents) getting quite frequent feedback on the learning that is occurring. As noted earlier in this book, that is one of the advantages of highly interactive, intelligent, computer-assisted learning.

There are many aspects of problem solving that cut across all disciplines. One is foresight. What will be the consequences if I make and implement a certain decision? This planning and analyzing consequences is fundamental in game playing and in all problem solving. The book Moursund (2006a) illustrates about 30 different major aspects of problem solving that can be explored in game-playing environments.

### **Competition, Independence, Cooperation**

Each game can be analyzed from a point of view of its:

- Cooperation/collaboration .
- Competition leading to the determination of winners and losers.
- Independence (not cooperative, not competitive) ,

This is important because people vary considerably in the levels of cooperation, independence, and competition they are comfortable with and seek in their everyday lives and in their schools. We can design educational games that have characteristics that best fit with the needs of the learners.

Research in education supports the cooperative/collaborative approach over the competitive approach. This research indicates that designing schooling along cooperative/collaborative approaches is more effective than designing them along competitive lines. Quoting from Tucker-Ladd (2000):

Actually, hard research data documents that people achieve more if they work cooperatively with others (than if they work competitively). We are so brainwashed, we find that hard to believe. (Think of it this way: trying to do your best is very different from trying to beat everyone else.) On the other hand, we can readily accept that a competitive job, school, or social situation, where someone wins by making others fail, causes dreadful stress, resentment of the winner, contempt for the losers, low self-esteem, and major barriers to warm, caring, supportive relationships. What is the solution? Kohn recommends replacing competition with cooperation, i.e. working together, assuming responsibility for helping each other do our best, and uncritically valuing each other's contributions. We need lots of research to help us to know when and how to reduce our competitiveness.

## **Massively Multiplayer Online Games (MMOG)**

Nowadays, it is no big deal for many thousands of people to be making simultaneous use of a computer system that processes game moves. In such a game, a player controls one or more virtual characters. Some of the games that have been developed can have tens of thousands of simultaneous players.

In many online games, players organize themselves into teams. A team, consisting of cooperating humans each running an individual character within the game, Each character and team carries out activities that may include fighting or in some other way competing against other teams being run by human players, against teams being run by a computer, or perhaps just in overcoming major challenges being generated by the computer system.

It is easy to draw parallels between this and a team of workers in a company competing against workers from other companies and participating in the overall world of business to develop products that capture market share and make profit for the company. It is now common for a team of researchers, located throughout the world, to work together on a project. Indeed, it is now common for certain types of jobs to be filled by telecommuters located thousands of miles from their employers and customers.

## **Working With Your Children and Their Schools**

Here is a brief summary of games in education.

1. Games can be used to create learning environments that are intrinsically motivating, attention grabbing, and attention holding. These characteristics mean that games have considerable educational potential.
2. Games create situated learning environments in which one can study their own learning, practice learning to learn, and easily see their increasing level of expertise that results from the learning. Parents and teachers can help students learn to learn about themselves and learning in such game environments.
3. Some simulation games (such as airplane pilot trainers) are so similar to corresponding "real world" activities, that there is automatically a considerable transfer of learning from the simulation to the real world. Many other games are weaker in this regard. For them, educational value is substantially increased by explicit instruction from parents and teachers.
4. Any game can be used to help teach important aspects of the curriculum, such as problem solving, competition, independence, cooperation, learning about oneself as a learner, and so on. Again, parents and teachers play a major role in making explicit the desired learning outcomes.

## Chapter 19: A Few Other Important Topics

“Students cannot possibly learn everything of value by the time they leave school, but we can instill in them the desire to keep questioning throughout their lives.” (Grant Wiggins)

"It is bad enough to reinvent the wheel. What really hurts is when they reinvent the flat tire." (Lee Shulman, Stanford University)

When I began writing this book, my intent was to keep it to less than 100 pages. I almost achieved that goal.

However, I have succeeded mainly because I left out a number of topics that could have been included. This last chapter is a brief treatment of some of these topics. Each is worthy of a whole chapter. Perhaps sometime in the future, when I am revising this book, I will decide to expand the book.

### Roles of Computers in Math Problem Solving

My doctorate is in math, and I been involved in math education throughout my professional career. From early on, I explored math education from a computer-oriented point of view. How do computers affect the instructional content, the teaching processes, and the assessment in our math education system?

My answers to this question are contained in the following book, which is available free on the Web:

Moursund, D.G. (June 2006). Computational thinking and math maturity: Improving math education in K-8 schools. Access at <http://darkwing.uoregon.edu/~moursund/Books/EIMath/EIMath.html>.

Quite a bit of my answer is summarized by a discussion of the diagram in Figure 19.1.

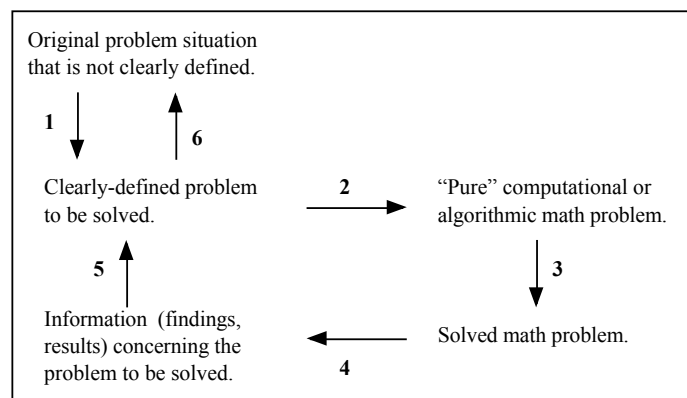


Figure 19.1. Six steps in solving a math problem.

Probably two-thirds to three-fourths of math education time at the K-12 levels is spent on step 3 in the diagram. How do you add, subtract, multiply, and divide integers, decimal fractions,

fractions, and algebraic expressions? How do you solve various types of equations? It is obvious that such manipulative skills are needed if one is to use math in solving really world problems.

However, for more than 20 years we have had inexpensive hand held calculators that can do the arithmetic operations. For more than 20 years we have had microcomputers that can do algebraic operations and solve the time of problems that students study in algebra courses. In summary, we spend most of our math education time teaching students to do things that calculators and computers can do. Much of this time would be better spent on the five other steps illustrated in the diagram. They are steps that require thinking and understanding, and computers are not good at those steps.

### **ICT as Part of the Content of Each Discipline**

The diagram in Figure 19.1 can be modified to fit problem solving in any discipline. From an education point of view, the issue is mainly the extent to which ICT affects step 3 in the diagram for solving problems in various disciplines. The schools, colleges, and universities that provide instruction in a discipline make their own decisions about how to deal with the ICT impact.

For example, the University of Oregon where I work has a large School of Architecture and Allied Arts. Within this School, the Art Department has created a degree program in Digital Arts. It has grown rapidly and now has several hundred students seeking undergraduate degrees. Within Architecture, a decision was made to require all students to own computers. Instruction in use of these computers is part of the initial coursework. All subsequent coursework assumes that students know how to use a computer.

Other areas at the University of Oregon that make extensive use of computers include Business, Journalism, and Music. Many other programs of study make only minimal use of computers. Sure, essentially all students at the University of Oregon have email accounts, write using a word processor, and use the Web to do information retrieval. However, relatively few other disciplines include a strong stress (and the option to do a minor or a major) in roles of computes within their disciplines.

The precollege integration of ICT into the content of various disciplines has been slow. Graphing calculators are now routinely used in high school math courses. Students emphasizing a business curriculum in high school learn to make extensive use of computers. Some high schools offer programs in engineering drawing or graphic arts, and they make extensive use of computers.

Some middle schools and high schools have a significant amount of digital music hardware and software. Such facilities make it possible to teach students to compose, edit, and perform electronic music. A few elementary schools have successfully experimented with these components of music education. See, for example, [http://www.apple.com/education/garageband/lesson\\_plans/](http://www.apple.com/education/garageband/lesson_plans/).

### **Designing and Constructing Robots**

There are a variety of commercially available robot construction kits. In addition, there are kits of components that can be used to build a variety of computer-controlled toys. A Google search on the quoted expression "*robot construction kit*" returned 258 hits on 8/11/06. The Website <http://robots.net/rcfaq.html> contains a list of robot contests and competitions. A number of schools participate in such competitions.

The company that makes Lego building blocks and a company that makes available the Logo programming language and support materials for schools have joined forces to create Lego Mindstorms. The combination of Lego building blocks with computer-controlled motor and gear systems allows students to build an amazing range of toys and to write programs that control these toys. These are great for use in schools and at home.

## Computers and Art

Artists work in many different media, such as different types of paints, carving stone, wood and bones, weaving using various type of materials, and so on. As computers with printers became available, some artists began to experiment with computer and printer a medium. The steady improvement of computers and compute display systems has led to such things as:

1. Computer graphics becoming a major sub discipline in the field of computer and information science. See, for example, <http://www.siggraph.org/>.
2. Mechanical drawing and engineering drawing becoming computerized. Computer aided design and computer aided manufacturing (CAD/CAM) are now very widely used. See <http://en.wikipedia.org/wiki/CAD/CAM>.
3. Computerization of many of the steps in the design, layout, and production of hardcopy and electronic copy of materials. This is now often called desktop publication.
4. Computerized sewing and weaving machines.
5. Digital still and video cameras, along with powerful computer aids to editing such digital materials.
6. Computer controlled printing mechanisms that can print (build, one very thin layer at a time) sculptures and prototypes of parts to be manufactured.
7. The rapid increase in computer animation, computer-generated visual effects, and computer “stunt doubles” for humans in movies.

## Computers and Music

The recording, editing, and playback of sound (including music) goes back to many years before the development of computers. As computers became available, people began to experiment with the digitization of sound. This eventually led to us having music available on CD-ROMs and DVDs, a wide variety of music synthesizers, and a wide range of computerized equipment for composing, editing, and performing music.

This has had a major impact on the music industry. On the one hand it makes it possible for many more people to compose, edit, and perform music. On the other hand, it has greatly reduced the number of live (human) performers needed to perform music. While some “blockbuster” films still make use of full orchestras, even they make use of very sophisticated computerized recording and editing facilities.

It is possible to compose, edit, and play back music just using an ordinary, inexpensive, microcomputer. Indeed, there are children’s toys costing well under \$50 that include a keyboard and storage and editing facilities. There are quite sophisticate and quite inexpensive additions to a computer can provide a near-professional level of capabilities and quality. Many schools now make use of such facilities. For example, see <http://www.xtec.es/rtee/eng/tutorial/>.

## Computer and Information Science

Quoting from [http://en.wikipedia.org/wiki/Computer\\_science](http://en.wikipedia.org/wiki/Computer_science):

Computer science, or computing science, is the study of the theoretical foundations of information and computation and their implementation and application in computer systems. Computer science has many sub-fields; some emphasize the computation of specific results (such as computer graphics), while others (such as computational complexity theory) relate to properties of computational problems. Still others focus on the challenges in implementing computations. For example, programming language theory studies approaches to describing computations, while computer programming applies specific programming languages to solve specific computational problems.

Peter Denning's 1999 article, available at <http://www.idi.ntnu.no/emner/dif8916/denning.pdf>, gives an excellent history and overview of the field. According to Denning, "By the early 1960s, there was a sufficient body of knowledge to merit the first academic departments and degree programs" In 1969 I helped to found the Computer and Information Science Department at the University of Oregon, and I served as its first head, 1969 to 1975.

Like many early Computer and Information Science Departments, the University of Oregon's department was formed by faculty who split off from the Mathematics Department. Even today, computer science and mathematics are closely related disciplines. Quite a few colleges and universities have a combined department of Mathematics and Computer Science. Computer Science degree programs typically require two years of math at the level of calculus and above.

While school age children often start learning to use computers at the earliest grade levels, the serious study of computer science is usually taught in the 11<sup>th</sup> or 12<sup>th</sup> grade of high school. A number of high schools offer a computer science Advance Placement course. Typically this is an academically challenging course. For a course description, see <http://apcentral.collegeboard.com/courses/descriptions/1,,151-162-0-8879,00.html>.

## Working With Your Children and Their Schools

Our schools divide the curriculum into a number of distinct subjects. In elementary school, for example, a certain number of minutes per day (or, in some cases, minutes per week) will be devoted to reading, writing, math, science, social science, art, music, health, and physical education. To a large extent these subjects are taught independently of each other, although some schools stress "reading across the curriculum."

Once students get out of school, they are expected to be able to deal with the real world problems they encounter at work, at home, and in other parts of their everyday lives. Some of these problems will be quite discipline specific. For the most part, however, real world problems are interdisciplinary. Thus, adults must deal with drawing upon their discipline-specific education—often completed many years in the past—to solve interdisciplinary problems.

Our formal educational system is not good at preparing people to deal with interdisciplinary problems. ICT is interdisciplinary, and many of the tools it provides are interdisciplinary. Thus, ICT provides a good vehicle to help improve the interdisciplinary education of children. One way to do this is in the context of project-based learning. To learn more about roles of computers in interdisciplinary project-based learning see <http://darkwing.uoregon.edu/~moursund/PBL/>.

## Appendix 1: Some Good (Free) Web-based Resources

"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change." (Charles Darwin)

"Fortune favors the prepared mind." (Louis Pasteur)

There are a huge and steadily growing number of free, high quality, educational materials available on the Web. This Appendix gives a few examples that may prove useful to you and your children. While many schools and individuals make use of these materials, there are also many people who are not familiar with them. The resources are listed in alphabetical order, and each contains a brief summary.

ASCD (n.d.). A lexicon of learning. Association for Supervision and Curriculum Development. Retrieved 7/11/06:

<http://www.ascd.org/portal/site/ascd/menuitem.4247f922ca8c9ecc8c2a9410d3108a0c/>.

Each discipline develops and makes use of special vocabulary that aids in effective communication among people who know the discipline. People outside of education use the term *educationalize* to describe the language of educators. Quoting from the Website:

Ever wondered what educators mean when they refer to "authentic assessment" or "Bloom's Taxonomy"?

Education, like all professions, has a specialized vocabulary that parents and others may have a difficult time understanding. This online dictionary, A Lexicon of Learning, provides clear definitions of educational terms in everyday language.

Civil War Maps (n.d.). *The valley of the shadow*. Retrieved 7/11/06:

<http://www.wwnorton.com/catalog/spring99/valleyshadow.htm>.

This Website provides a good example of very high quality educational use of the Web. As you explore these materials, compare and contrast with static textbooks. Quoting from the Website:

The Valley Project is working on three map archives. The first is a map collection of original Civil War maps. These include maps from the Official Records Atlas and from the Jedediah Hotchkiss collection at the Library of Congress. The second is a set of three dimensional, geographically accurate maps of battlefields and regions. At the Institute for Advanced Technology in the Humanities, we are working on producing these exciting maps. The third map archive includes battle field movies of virtual reality worlds, rendered in CosmoWorlds™. These movies are large and downloading them may take some time, but they provide an animated view of the battle unfolding over time.

Digital Commons (n.d.). Build your custom Institutional Repository the quick and easy way.

Retrieved 8/2/06: [http://umi.com/products\\_umi/digitalcommons/](http://umi.com/products_umi/digitalcommons/).

There are a growing number of higher education institutions that belong to the Digital Commons movement. Each makes available a large and growing collection of materials from their own institution. About 50 institutions are listed on the Website named above. As an

example, I looked at Oklahoma State University. Their site indicated that 404 full text documents were added in the past week.

Free education applications and learning materials. See <http://www.concord.org/publications/newsletter/2005-spring/opensource.html> for a nice discussion of this area as well as access to a number of good, free educational applications. For example (quoting <http://www.concord.org/work/themes/sustainable.html>):

**Sustainable Development Education: Confronting global issues with decision-making tools**

One of the most complex and important issues facing future generations is how to manage the trade-offs between resource use and quality of life. [The Center for a Sustainable Future \(CSF\)](#), a division of the Concord Consortium, has developed models, curricula, and online teacher professional development materials around this issue. The center also works intensively with organizations of all types throughout the world in integrating sustainability into their thinking.

Through its five-year project [Education for a Sustainable Future](#), CSF has developed and disseminated over 60 technology-based curricular units that help students better understand their futures. The center has created three specific pieces of software aimed at helping learners better understand key principles of sustainable thinking.

Retrieve this software from <http://www.concord.org/research/sustainable.htm>.

Free Software Movement. A 7/19/06 Google search of "*Free Software Movement*" produced about 436,000 hits.

The "mainstream" applications software made available through commercial software developers and vendors tend to be expensive. There is a growing movement of volunteers who develop software and make it available free. To learn more about the Free Software Movement, see <http://www.gnu.org/philosophy/philosophy.html> and [http://en.wikipedia.org/wiki/Free\\_software\\_movement](http://en.wikipedia.org/wiki/Free_software_movement).

There is a huge range of software available free. Here are a few examples of free products.

**Products Somewhat Similar to Various Components of Microsoft Office**

- AbiWord <http://www.abiword.com/>. Word processor
- ajaxWrite <http://www.linspire.com/ajaxwrite.php>. Word processor.
- Irows <http://www.irows.com>. Spreadsheet.
- Thumb Stacks <http://www.thumbstacks.com/>. Desktop presentation (slide show).
- Writely <http://www.writely.com> (owned by Google). Word processor.
- Zoho Creator <http://www.zohocreator.com/>. Database.

**Programming Languages**

A variety of free programming language compilers and interpreters are available. See, for example, <http://www.thefreecountry.com/compilers/index.shtml>. Generally speaking, a reasonable level of computer technology knowledge and skill is needed to download programming languages and learn to use them. Both BASIC and Logo have been widely used at the K-12 levels.

**Games and Puzzles**

Typically, Web sites that provide free puzzles and games make income to sustain themselves by selling ads, selling games and puzzles, selling game and/or puzzle subscriptions or memberships. However, there are a huge number of Web sites where some free games and puzzles are available.

Moursund's (June 2006a) free book discusses a number of games and puzzles and some of their uses in education. A number of the games and puzzles are available free on the Web, and the book contains sources for some of these.

Puzzles are typically designed to be mental challenges. Here are four good sources of free puzzles:

- [http://www.puzzlechoice.com/pc/Puzzle\\_Choicex.html](http://www.puzzlechoice.com/pc/Puzzle_Choicex.html)
- <http://www.aimsedu.org/Puzzle/>.
- <http://www.freepuzzles.com/>.
- <http://perplexus.info/tree.php>

ISTE NETS (n.d.). International Society for Technology in Education. Retrieved 7/19/06:  
<http://www.iste.org/>.

ISTE is a large non-profit professional society dedicated to the improvement of education through appropriate use of ICT. It has developed ICT standards for PreK-12 students, for teachers, and for school administrators. Details on these standards are available at <http://cnets.iste.org/>.

ISTE works with the National Council for Accreditation of Teacher Education to help set the ICT standards of teacher education programs. To learn more about NCATE, go to <http://www.ncate.org/>.

ISTE includes a Center for Applied Research in Educational Technology. CARET bridges education technology research to practice by offering research-based answers to critical questions. See <http://caret.iste.org/>.

Juggling (n.d.). Vova and Olga Galchenko who are two of the worlds' best jugglers. Retrieved 8/11/06: <http://www.time.com/time/juggling/>.

If you have a reasonably fast connection to the Web, you will likely enjoy Vova and Olga Galchenko who are two of the worlds' best jugglers. The first video shows the older boy when he was about six or seven years old. He was already an accomplished juggler. The ninth video shows him at age 15, working as a team with his 12-year-old sister. Individually and together, they are world class! They have worked many hours a day for many years to achieve their current level of expertise. See also, [http://en.wikipedia.org/wiki/Vova\\_Galchenko](http://en.wikipedia.org/wiki/Vova_Galchenko).

NASA (n.d.). National Aeronautics and Space Administration education. Retrieved 7/11/06:  
<http://education.nasa.gov/home/index.html>.

The National Aeronautics and Space Administration invests heavily in elementary and secondary school education and in informal education. There is a wealth of materials available free on their Website. Quoting from the Website:

The two main goals of NASA's education program are to "inspire and motivate students to pursue careers in science, technology, engineering, and mathematics" by supporting education in the Nation's schools and to "engage the public in shaping and sharing the experience of exploration and discovery" by supporting informal education and public outreach efforts. NASA's commitment to education places special emphasis on these goals by increasing elementary and secondary education participation in NASA programs; enhancing higher education capability in science, technology, engineering, and mathematics (STEM) disciplines; increasing participation by underrepresented and underserved communities; expanding e-Education; and expanding NASA's participation with the informal education community.

NSDL (n.d.). National Science Digital Library. Retrieved 7/11/06: <http://nsdl.org/>.

The National Science Digital Library is a free resource funded by the National Science Foundation. It is a free digital library of resources for science, technology, engineering, and mathematics education and research. Much of the material made available through their Website is designed for K-12 teachers and their students. Quoting from the Website:

Resources available through NSDL include images, video, audio, animations, software, datasets, and of course text documents such as journal articles and lessons plans. In addition, NSDL provides services such as search, browse, help, "Ask-An-Expert" services, news reports, and online community discussions.

Self-assessment. There are a number of self-assessment instruments available on the Web. For example, are you interested in obtaining a quick estimate of your IQ? Use a search engine to search on the expression "*free IQ test*" and you will get a large number of hits.

How about self-assessment in ICT? As a very rough rule of thumb, people can be divided into three categories.

- Those who say, "I can't do computers."
- People who know a little about computers and think they know a lot.
- People who know quite a bit about computers and realize that their knowledge and skill is rather limited.

For example, perhaps you and your school age children make use of a word processor and feel confident in your knowledge and skill in this particular computer application. There is a good chance that the second bulleted item given above applies in this case.

Five specific self-assessment instruments I developed for preservice and inservice teachers are given at <http://darkwing.uoregon.edu/%7emoursund/ICT-planning/table-sa-instruments.htm>. For example, rate yourself or your children on a scale of 1 to 7 (1 is very low, 7 is very high) on your knowledge of word processing. Make use of the following brief description of some of the capabilities of a word processor:

A modern word processor contains hundreds of aids to writing, designing, and editing for effective "hard copy" communication. For example, it may contain special aids to help create headers, footers, page numbering, tables, styles, index, and table of contents. It may contain an outline, provisions for arranging a list in alphabetical or numerical order, provisions for inclusion of and editing of graphics, and provisions for establishing Web links. It contains provisions for setting a first line indent and a hanging indent. It contains provisions to make use of a variety of typefaces and type sizes. It contains a spelling checker and may contain a grammar checker. It contains provisions for saving files in a variety of formats, including RTF and PDF. It may contain special provisions for editing word-processed documents written by others.

The point to the above exercise is that a word processor such as Microsoft Word contains a very large number of features that most people never use. The features are included because quite a few are useful to lots of people, and still more are useful to people who are making professional level use of the software.

StudyBuddy (n.d.). *A free search engine built just for homework*. Retrieved 8/11/06: <http://homework-help.aol.com/>.

This is an example of a search engine designed to help keep children from reaching inappropriate Websites. Quoting from the Website:

StudyBuddy.com is an education Web site and homework help destination for students in grades K-12. It features an easy-to-use search engine with dependable results, reference tools, fun activities, games and more. You can find better answers faster and easier with StudyBuddy.

...

StudyBuddy Search returns the most relevant information. And it is well organized to meet the requirements of homework assignments. You can rest assured that the info you are seeing is trustworthy. No more navigating to random Web sites that make you wonder if the info there is true. Everything that appears in StudyBuddy is "homework approved."

Homework approved means that you can use any of the info you find in StudyBuddy with confidence. StudyBuddy takes its commitment to education seriously. A specialized team of certified teachers and librarians reviews hundreds of Web sites each week and selects only those of quality which will enhance the K-12 learning experience.

Wikipedia (n.d.). *Wikipedia, the free encyclopedia*. Retrieved 7/11/06:

[http://en.wikipedia.org/wiki/Main\\_Page](http://en.wikipedia.org/wiki/Main_Page).

The Wikipedia free encyclopedia project began in 2001 and as of mid 2006 contains more than 4,600,000 articles—about 1,200,000 are in English. This is a huge, multi author encyclopedia with the authors contributing their services free. It has the peculiar and interesting characteristic that anybody can contribute a revision to most of the articles. I, personally, find it Wikipedia to be a very useful and high quality source of information. Quoting from the Website:

Wikipedia's co-founder, Jimmy Wales, has called Wikipedia "an effort to create and distribute a multilingual free encyclopedia of the highest possible quality to every single person on the planet in their own language." However, there has been controversy over Wikipedia's reliability and accuracy, with the site receiving criticism for its susceptibility to vandalism, uneven quality and inconsistency, systemic bias, and preference for consensus or popularity over credentials. Nevertheless, its free distribution, constant and plentiful updates, diverse coverage, and versions in numerous languages have made it one of the most-used reference resources on the Internet.

Willard, Nancy E. (n.d.). Center for Safe and Responsible Internet Use. Retrieved 7/19/06:

<http://www.csriu.org/about/bio.html>.

Dr. Willard's Website contains access to a variety of free materials about protecting children from people who make abusive uses of computers. She also writes books on these topics that are commercially available. Quoting from her Website:

Willard is the author of a book entitled *Computer Ethics, Etiquette, and Safety for the 21st Century Student*. This book is published by the International Society for Technology in Education. She has written articles that have been published by major educational publications. Links to many of these articles are on the Center's web site.

In the last two years, Willard has been focusing her attention on the issue of cyberbullying and related concerns. An early pioneer in recognizing the concern, she has placed highest attention of the development of a research-based strategy for schools, working in partnership with the community, to address this concern. She has expanded her previous understandings of human online behavior, law, and Internet use in schools with a study of bullying research, effective violence, bullying, and suicide prevention programs, and school-based threat assessment.

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