Introduction to Information and Communication Technology in Education

"Smooth seas do not make skillful sailors." (African Proverb)

"You can lead a horse to water, but you can't make it drink." (A familiar adage.)

1/1/05

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Preface

"Without a struggle, there can be no progress."
(Frederick Douglass, 1819-1895)

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

Information and Communication Technology (ICT) is a major challenge to our educational system. This book is designed for use by PreK-12 preservice and inservice teachers, and by teachers of these teachers. It provides a brief overview of some of the key topics in the field of Information and Communication Technology (ICT) in education. I wrote this book to help serve the needs of my students in a course titled Teaching and Learning in the Digital Age. You can access a syllabus for that course at
http://darkwing.uoregon.edu/~moursund/DigitalAge1/index.htm.

The mission of this book is to help improve the education of PreK-12 students. A three-pronged, research-based approach is used.

Goal # 1 of this book is to help you increase your expertise as a teacher. There is substantial research that supports the contention that students get a better education when they have "better" teachers.

Goal # 2 of this book is to help increase your knowledge and understanding of various roles of ICT in curriculum content, instruction, and assessment. There is significant research to support the benefits of ICT in these three areas. In addition, ICT is now an important content area in each of the disciplines that you teach or are preparing to teach.

Goal # 3 of this book is to help you increase your higher-order, critical thinking, problem-solving knowledge and skills. Special attention is paid to roles of ICT as an aid to solving complex problems and accomplishing complex tasks in all curriculum areas. Research suggests that US schools are not nearly as strong as they could be in helping students gain increased expertise in problem solving and critical thinking.

Now that I have stated goals for this book, I want to make clear a non-goal. **This book is not designed to help you learn specific pieces of software.** The typical first ICT in Education course for preservice and inservice teachers has a strong focus on learning to make use of various pieces of hardware, software, and connectivity. This book is not designed as a substitute for, or a major aid to, learning these rudiments of ICT that are now being learned by many students before they get to college.

This book is designed to addresses some of the weaknesses of typical first or second ICT in education courses that overemphasize learning computer applications and underemphasize other aspects of the field of ICT in education. The book focuses on general topics such as ICT in curriculum, instruction, assessment, increasing problem-solving expertise of students, and in other aspects of a teacher's professional work. The emphasis is on higher-order knowledge and skills.

Alternatively, this book can be used in a second ICT in education course for preservice and inservice teachers, building on the "basic skills" taught in a first course. However, throughout the

book we argue that basic skills (lower-order knowledge and skills, rudimentary use of some of the general purpose pieces of computer software) should be integrated in with higher-order knowledge and skills.

The prerequisite for a course using this book is an introductory level of knowledge and skill in using a word processor in a desktop publication environment, using email, and using the Web. Nowadays, large numbers of students meet this prerequisite by the end of the 5th grade, since such knowledge and skills are only part of the 5th grade standards for students established by the International Society for Technology in Education (ISTE NETS n.d.). Increasingly, instruction in such basic skills is not considered to be an appropriate part of a college-level curriculum that carries credit towards a college degree.

As you read this book, you will come to understand that ICT in education is a broad, deep, and rapidly growing field of study. ICT has the potential to contribute to substantial improvements in our educational system. To date, relatively little of this potential has been achieved. Moreover, the pace of change of the ICT field currently exceeds the pace of progress in making effective use of ICT in education. Thus, the gap between the potentials and the current uses of ICT to improve PreK-12 education is growing.

ICT is a very rapidly changing field. What can you learn, and what can you help your students learn, that will last for decades or a lifetime, rather than just until the next "new, improved, better, faster, more powerful" ICT product appears on the market? This book will provide you with some answers.

David Moursund

January 2005

Chapter 0

Big Ideas

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

"Civilization advances by extending the number of
important operations which we can perform without
thinking of them." (Alfred North Whitehead)

It is assumed that you are reading this book because you are a preservice or inservice teacher, and/or because you are interested in learning more about how computers can contribute to improving our educational system. Relatively few people thoroughly read an entire textbook. Their enthusiasm, interest, and energy level tends to wane as the book drags on and on. Thus, they often don't reach the last chapter, which might be the most vital.

To address this problem, I have done two things. First, I have kept this book relatively short. Second, I have placed a large chunk of my intended last chapter at the beginning. Since it comes before the ordinary first chapter, I have numbered it Chapter 0. Chapter 0 contains a brief introduction to and summary of the Big Ideas (the unifying, very important themes) covered in this book.

I hope that your reading of this chapter will lead you into reading subsequent chapters. When (and if) you reach the end of this book, please come back and read Chapter 0 again. You may be pleasantly surprised by how much you have learned!

The field of Information and Communication Technology (ICT) combines science and technology. It includes the full range of computer hardware and software, telecommunication and cell phones, the Internet and Web, wired and wireless networks, digital still and video cameras, robotics, and so on. It includes the field of Computer and Information Science and a huge and rapidly growing knowledge base that is being developed by practitioners and researchers. ICT has proven to be a valuable aid to solving problems and accomplishing tasks in business, industry, government, education, and many other human endeavors. This remainder of this chapter lists a few of the Big Ideas (the important, long-lasting, unifying ideas) that have guided the development of the material in this book.

Big Idea 1: Problem Solving Using Body and Mind Tools

The diagram of Figure 0.1 illustrates the single most important idea in this book. The idea is that properly educated people, using tools that aid their physical bodies and their minds, can solve a wide variety of challenging problems and accomplish a wide variety of challenging tasks. In approaching these problems and tasks, sometimes people work in multi-person teams and sometimes they work in one-person "teams." Many other people, through the collective knowledge and tools of the human race, assist even a one-person team.

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│ Tools to extend              Tools to extend physical │
│ mental capabilities.         capabilities.            │
│  ╲                                            ╱       │
│   ╲        Problem-Solving,                  ╱        │
│    ╲      Task-Accomplishing                ╱         │
│     ╲           Team                       ╱          │
│      ╲                                    ╱           │
│       ╲                                  ╱            │
│        ╲                                ╱             │
│         ╲                              ╱              │
│          ╲                            ╱               │
│           ╲                          ╱                │
│                        ▼                              │
│ Formal and informal education and training to build mental and │
│ physical capabilities and one's knowledge and skills to effectively │
│ use mental and physical tools individually and as a team member. │
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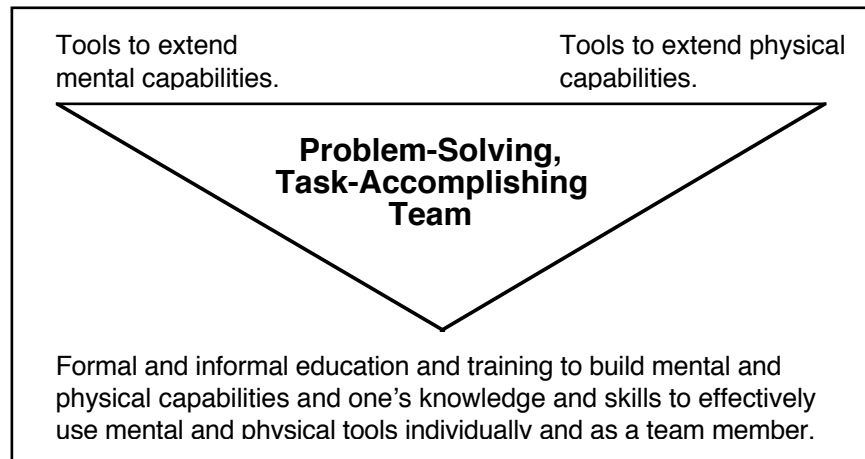
Figure 0.1. Problem-solving, task-accomplishing team.

The center of the diagram is a person or group of people working to solve a problem or accomplish a task. The top part of the diagram focuses on the idea that throughout human history, humans have been developing tools to enhance the capabilities and performance of their bodies and minds. Think about:

- The time hundreds of thousands of years ago when our ancestors developed the making of fire, the stone ax, the spear, and the flint knife as tools to enhance the food gathering and use capabilities.

- Eleven thousand years ago when humans began to develop agriculture, along with the tools and methodologies to raise and effectively use crops and farm animals.

- Five thousand years ago when humans developed written language, a very powerful mind tool. Reading, writing, and arithmetic were developed as an aid to solving the problems and accomplishing the tasks of a thriving and growing agricultural society.

Reading, writing, and arithmetic were the first tools that required a formal and protracted education system. Up to that time, the body and mind tools could be learned through informal education and apprentice systems. After that time, we began to have formal schools that have many of the characteristics of today's schools. The past 5,000 years have seen a huge growth in the number of students receiving formal education and the length of that formal education.

Also during the past 5,000 years, many new body and mind tools have been developed, and many of these have been widely adopted. In terms of the diagram of Figure 0.1, this means that our informal and formal educational system has been faced by the need for continual change in order to appropriately accommodate the changing tools.

A library can be thought of as being a mind tool. It facilitates the single most important aspect of problem solving—building on the previous work of others (Moursund, 2004a). The Web is a global library that is steadily growing in the depth and breadth of its contents. Communication over distance and time is an essential component of building on the work of other people. Thus, the Internet (which includes the Web) is of steadily growing importance in education.

Over a period of thousands of years, there has been steady progress in "automating" or partially automating mind and body tasks. Automated factory tools are, or course, an obvious example of this progress. But, consider the development of inexpensive paper and writing

instruments, and the development of algorithms for "paper and pencil" arithmetic computation. The combination of paper, pencil, and such algorithms is a powerful aid to the human mind in representing and solving arithmetic computational problems. ICT now plays a major role in factory automation. However, it is beginning to play an equally major role in the "automation" of processes that the mind carries out. More and more mental tasks are being aided by and/or carried out by ICT systems.

Such uses of ICT raise a critical educational issue: **If an ICT system can solve a type of problem or accomplish a type of task that we currently teach students in school to do without use of ICT, what should we now be teaching students about this problem or task?**

Big Idea 2: ICT is a Change Agent

The invention or development of a new physical body or mental tool creates both opportunities and challenges. In brief summary, a new tool typically:

1. Helps us to "better" solve some problems and accomplish some tasks that we are currently addressing without the new tool. Here, the term "better" may have meanings such as: in a more cost effective manner; faster; more precisely; more reliably; with less danger; and so on.

2. Helps us to solve some problems and accomplish some tasks that cannot be solved without the new tool.

3. Creates new problems. For example, the development of the 3Rs created the educational and social problems of who would receive a formal "grammar school" level of education focusing on these topics, and who would provide this education. This problem preceded the digital divide problem by about 5,000 years.

ICT is an example of a technology that is a powerful change agent. Going back to Figure 0.1, we can examine ICT from the point of view of how it contributes to tools that enhance our physical bodies. We now have microscopes, telescopes, brain scanning equipment, automated factories, and a huge range of other tools that are highly dependent on ICT.

We can also view ICT as a mind tool. It is evident that ICT incorporates and extends some of the power of reading, writing, and arithmetic. For example, the Internet facilitates global communication and the Web (a global library). ICT facilitates the automation of many mental activities.

ICT creates a number of problems in education, such as digital equity, the need for a relatively expensive addition to a school's infrastructure, and how to provide appropriate ICT education for preservice and inservice teachers. ICT in education creates problems of how to deal with potential changes in curriculum content, instructional processes, and assessment in a manner that leads to students getting a better education. ICT creates the problem of deciding what we want students to learn about ICT.

We are used to the idea that once a tool has been invented, it can be improved over time. However, humans have had little experience with tools that have been developed to a very useful level, and then subsequently improved by a factor of a million or more. The hardware capabilities of ICT are still changing very rapidly—doubling in capabilities over a time span of less than two years. This rapid pace of change is, in and of itself, a major challenge to our educational system.

Big Idea 3: Some Basic, Enduring Goals of Education

David Perkins' 1992 book contains an excellent overview of education and a wide variety of attempts to improve our educational system. He analyzes these attempted improvements in terms of how well they have contributed to accomplishing the following three basic and enduring goals of education (Perkins, 1992, p5):

1. Acquisition and retention of knowledge and skills.

2. Understanding of one's acquired knowledge and skills.

3. Active use of one's acquired knowledge and skills. (Transfer of learning. Ability to apply one's learning to new settings. Ability to analyze and solve novel problems.)

These three general goals—acquisition & retention, understanding, and use of knowledge & skills—help guide formal educational systems throughout the world. They are widely accepted goals that have endured over the years. They provide a solid starting point for the analysis of any existing or proposed educational system. We want students to have a great deal of learning and active use experience—both in school and outside of school—in each of these three goal areas.

You will notice that these three general goals do not point to any specific content areas. One of the reasons these goals have endured over the years is that they are flexible enough so that over time, people can make changes in curriculum content, instructional processes, assessment, teacher education, and so on. ICT is a powerful change agent in all of these aspects of our formal educational system. This book explores ICT from the point of view of the three goals stated by Perkins. It looks at ICT in terms of possible changes in curriculum content, instructional processes, assessment, teacher education, and so on.

Perkins' first goal focuses on acquisition and retention. One of the strengths of ICT lies in a combination of information storage and retrieval, and in the automation of tasks that that can be built on this type of accumulated knowledge. ICT systems are much more capable than people when it comes to quickly committing large amount of material "to memory" and retaining this memorized material perfectly over a long period of time.

Perkins' second goal focuses on understanding. What is your understanding of what it means for you or some other human to understand something? In what sense does a computer system "understand" something? As a preservice or inservice teacher, it is very important that you have clear insight into the similarities and differences between human understanding and ICT system understanding. In what ways do these two types of understanding complement each other?

Pay special attention to the third goal. There, the emphasis is on problem solving and other higher-order knowledge and skill activities. You know that ICT systems can solve or help solve a wide variety of problems. How does a computer's higher-order, problem-solving knowledge and skills compare with a human's higher-order and problem-solving knowledge and skills? In what ways do these two types of problem-solving and other higher-order knowledge and skills complement each other or compete with each other?

The diagram in Figure 0.2 represents Perkins' three goals of education from a lower-order to higher-order point of view. This representation of the three goals is intended to suggest that acquisition, retention, and understanding are all oriented toward being able to make effective use of what one is learning.

Perkins' Three Goals of Education

Lower-order

Higher-order

Acquisition and Retention

Understanding

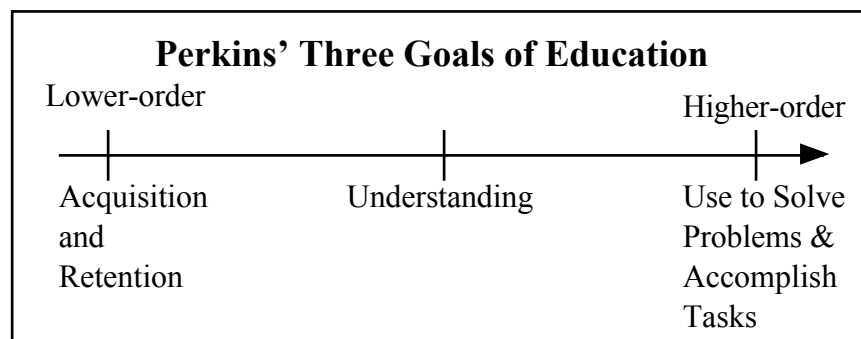Use to Solve Problems & Accomplish Tasks

Figure 0.2. Scale: lower-order to higher-order goals of education.

Bloom's taxonomy provides another approach to analyzing lower-order versus higher-order knowledge and skills. Bloom's 1956 scale (not an equal interval scale) uses the labels knowledge, comprehension, application, analysis, synthesis, and evaluation to define a continuum moving from lower-order to higher-order. At the second and third levels (comprehension and application) Bloom stresses that the student is expected to have understanding that allows transfer to solving problems and accomplishing tasks that he or she has not encountered before.

Note: Although this book contains a large number of citations and references, you can see that I did not provide one for Bloom's Taxonomy. When I recently did a Google search on Bloom's Taxonomy, I got about 48,000 hits. This reassures me that anyone who needs to read more about this important topic will be able to find appropriate reading material without my help. It also suggests a significant change that is going on in the "scholarly" world. Nowadays, I do much of my reading and other scholarly work sitting in front of (or, holding) a computer that is connected to the Internet. As I read, I often pause to check something out on the Web. I certainly hope that you (my readers) are developing similar habits of mind and will help your students to develop such habits.

There are other ways to define lower-order and higher-order knowledge and skills. A learner's point of view is represented in the diagram of Figure 0.3.

Expertise Scale Illustrating Lower–Order and Higher–Order Knowledge and Skills

Lower-order

Higher-order

Novice

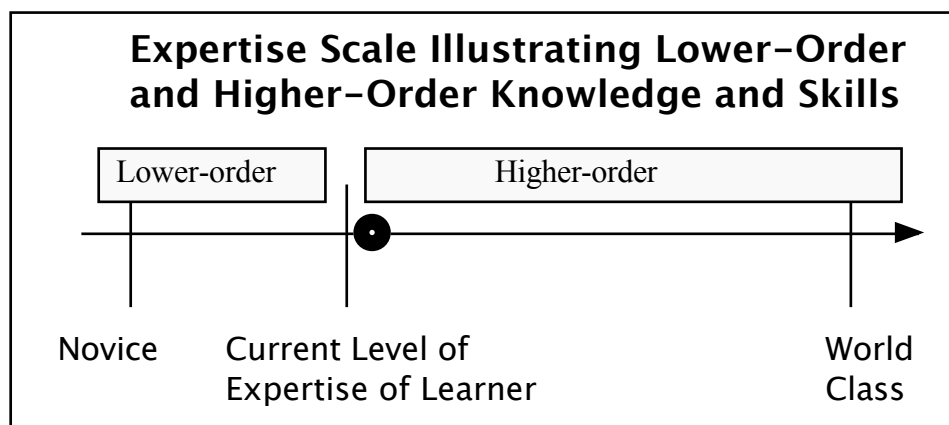Current Level of Expertise of Learner

World Class

Figure 0.3. A student's view of lower-order and higher-order.

The diagram of Figure 0.3 stresses that a student does not understand lower-order and higher-order as separate ideas. Rather, the student combines his or her lower-order and higher-order knowledge and skills to perform at a certain level of expertise within a domain. From this point

of view, "higher-order" is anything that helps the student gain increased expertise within the domain and builds upon current expertise. Thus, instruction should be at a level indicated by the large dot in the diagram—at a level somewhat higher than the student's current level of expertise. Obviously this creates some tension between instruction that focuses heavily on the lower-order knowledge and skill aspects of a domain, versus instruction that has been carefully designed to balance learning of lower-order and higher-order knowledge and skills to help a student gain increased expertise.

Figure 0.3 also illustrated a major difficulty of ICT in education from a teacher point of view. A teacher tends to think of any ICT knowledge and skill that he or she does not possess as being higher-order. But, some of his or her students may already think of some of this ICT knowledge and skill as being lower-order. Thus, the teacher may fail to facilitate students gaining such "advanced" (from the teacher point of view) knowledge and skills, while students are perfectly capable of gaining the knowledge and skills.

Big Idea 4: Developing and Increasing Expertise as a Teacher

There is a difference between having some level of expertise and being an expert. Within any domain or area of knowledge and skills that is under consideration, an expertise scale runs from a very low level to a very high level. The diagram in Figure 0.4 illustrates this idea through use of a general-purpose self-evaluation expertise scale for a preservice or inservice teacher. It cans be used in any aspect of being a good teacher, although the focus in the diagram is on an ICT expertise area such as a word processor or spreadsheet. For example, you might use it to consider your communications skills, your knowledge of the content of a particular content area, or your knowledge of the pedagogy of a particular content area.

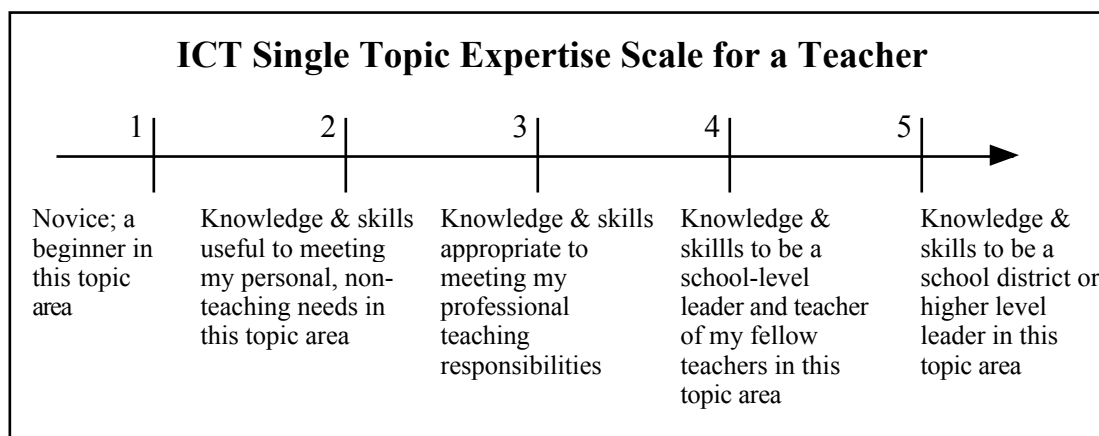|	**ICT Single Topic Expertise Scale for a Teacher**			
1	2	3	4	5
Novice; a beginner in this topic area	Knowledge & skills useful to meeting my personal, non-teaching needs in this topic area	Knowledge & skills appropriate to meeting my professional teaching responsibilities	Knowledge & skillls to be a school-level leader and teacher of my fellow teachers in this topic area	Knowledge & skills to be a school district or higher level leader in this topic area

Figure 0.4. A general-purpose expertise scale for a teacher.

We all know that a good teacher has an appropriate balance of expertise in the content of areas he or she teaches, and the pedagogy of teaching the content. Each content area that you teach or are preparing to teach is both broad and deep. The pedagogy of each content area is also broad and deep. What constitutes an "appropriate balance" between content and pedagogy expertise for an individual teacher varies with the content area, the teacher, and the maturity of the students, and so on.

As a teacher, you want to help your students move up expertise scales that correspond to the topics and subject areas that you teach. A high level of expertise in a domain is exemplified by

high knowledge and skill that is efficiently and effectively applied to solving the problems and accomplishing the tasks of the domain. Here are a few things to be aware of:

1. Learners brings existing knowledge and skills to whatever new learning task they face. This situation is the core of constructivism, which is an important component of the Craft and Science of Teaching and Learning we discuss in the next section of this chapter. This situation is also central to the idea of developing an Individual Education Plan (IEP) for a student.

2. Learners vary in their innate mental, physical, emotional, social, and other capabilities. Note, however, that the "nature versus nurture" issue is very complex. As teachers, our goal is to help our students to develop knowledge and skills that move them up various expertise scales. Some students will move up faster and some have the potential to move up further than other students. All have the potential to gain increased expertise with a domain.

3. It is very difficult (indeed, for the most part it is impossible) to accurately predict a long time in advance either how fast a learner will move up an expertise scale or how far along the scale the learner might progress. One of the things that educators have learned is that setting high goals and standards is usually very desirable. But, this must be done using common sense. Most children will not become world-class athletes or world-class scholarly researchers.

4. Increasing expertise draws upon a combination of lower-order and higher-order knowledge and skills. While lower-order and higher-order can be taught and practiced somewhat separately from each other, seamless integration is a goal. Educational research and practice suggests that this integration should be inherent to the teaching and learning process at all grade levels.

After a person achieves a certain level of expertise, this level is not automatically retained. Generally speaking, it takes practice to maintain a certain level of knowledge and skill. At some stage in one's physical and mental development, an aging body and/or aging mind tend to decrease one's capabilities. Finally, over time the top end of the expertise scale tends to move to the right.

As an example, consider a fully competent doctor whose medical practice work is sufficient to maintain his or her current levels of knowledge and skills. Then imagine major progress in the field of medicine based upon development of new technologies and treatment methodologies. These developments "raise the bar"—in effect, they increase the level of expertise the doctor needs to be as good as he or she was.

This medical doctor story is applicable to teachers. ICT knowledge, skills, and effective use are very important components of expertise in many areas, including teaching. A teacher who is not gaining appropriate and increasing ICT knowledge and skills and incorporating this into curriculum, instruction, and assessment is actually decreasing in a very important component of his or her level of expertise as a teacher.

Big Idea 5: Craft and Science of Teaching and Learning

We now have 5,000 years of accumulated knowledge about teaching and learning in school environments. This knowledge is called the Craft and Science of Teaching and Learning.

Teachers and researchers have accumulated a huge amount of information about effective teaching and learning. As an example, consider the idea of teaching and learning in a manner that facilitates both retention and transfer to problems and tasks one will encounter in the future. The past two decades have witnessed the development of a low-road, high-road theory of transfer. This theory helps us to design curriculum content and instructional processes that improve our accomplishment of the three educational goals listed by Perkins.

The stimulus-response theory of B.F. Skinner has been supplemented and to a great extent superseded by a variety of cognitive learning theories. An understanding of early childhood development and learning has led to Head Start programs. An understanding of vitamins and chemicals has led to the addition of folic acid and other vitamins in a variety of our foods, and to removal of lead paint and leaded gas from our environment. We have a growing understanding of the effects of class size and the value of tutoring or very small group instruction.

As another example, considering helping dyslexic students learn to read. Shaywitz (2003, p6) indicates that some level of dyslexia may affect as many as one-fifth of all students. Thus, as a regular classroom teacher you are very apt to have one or more students with some degree of dyslexia. Brain science researchers have identified differences in brain "wiring" between students who readily gain fluency (speed and accuracy) in reading, and those who don't. The brain imaging equipment used by the brain researchers is dependent on powerful computers as well as other technology.

Reading specialists and brain scientists are now working together to develop effective methods to help dyslexic students to learn to read well. Some of their successful approaches make use of highly interactive computer-assisted learning. Often this computer-assisted learning is delivered over a telecommunications system, such as the Internet. In addition, dyslexic students benefit greatly from learning to use a word processor to do their writing (including doing the writing on tests) and being given more time to take tests.

In summary, we know lots of ways to improve education. However, we are not particularly successful in the wide scale implementation of our steadily growing understanding of the Craft and Science of Teaching and Learning. ICT provides us with tools that can help substantially in this endeavor.

Big Idea 6: Taking Responsibility for Your Own Learning

A baby or toddler is naturally inquisitive, intrinsically motivated, and an omnivorous learner. A huge amount of learning occurs in the informal educational environment provided by the caregivers. We know that the quality of this environment makes a huge difference (on average) in the learning and cognitive growth of young children. Thus, many children reaching the kindergarten age are a year or more behind the "average" while many others are a year or more ahead. Head Start programs have shown that it is possible to significantly improve the situation for the laggards.

One of the goals of our formal educational system is to help each student develop an increasing level of expertise as independent, self-responsible, self-sufficient, intrinsically motivated learner. Educational researchers know quite a bit about adult learners, and this knowledge provides us with some insights into how well our formal educational system is doing in helping students learn to learn and learn to take responsibility for their own learning. We know that there are very large variations in our level of success in meeting goals of students becoming increasingly responsible for their own learning.

ICT enters this topic area in three key manners:

1. Access to aids to learning. ICT brings us the Internet, the Web, Computer-Assisted Learning, and Distance Learning.

2. Self-assessment and other aids to measuring one's progress toward meeting one's personal learning goals. (Use a Web search engine to search for self-assessment. Perhaps you will be surprised by the huge number of "hits" that you obtain. I got over 4 million hits using Google in December 2004.) Typically, Computer-Assisted Learning and Distance Learning include aids to measuring one's progress—that is, aids to self-assessment.

3. Individualization, and providing increased opportunities for a student to pursue his or her areas of deep interest and passion. Intrinsic motivation is a very important aspect of education.

Final Remarks

The diagram given below in Figure 0.5 helps to unify the ideas in this chapter. This diagram emphasizes the idea that ICT systems all by themselves can solve some problems and accomplish some tasks much better than people. We also know that people, without the use of ICT systems, can solve many problems and accomplish many tasks much better than ICT systems. Finally, the diagram indicates that that there are many problems and tasks where people and ICT systems working together can out perform either ICT systems or people working alone.
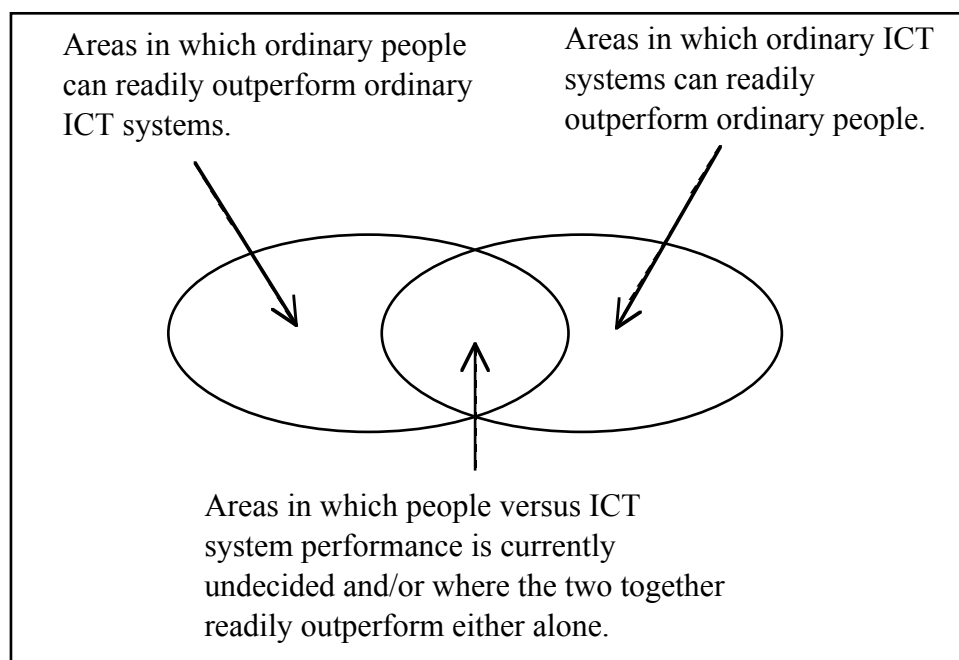

Figure 0.5. People versus ICT systems

All teachers are faced by the issues raised in the diagram of Figure 0.5. A major goal in preservice and inservice teacher education is to help prepare teachers to effectively deal with this challenge. Curriculum content, instructional processes, and assessment need to take into consideration the basic framework of this diagram.

The mission of this book is to help you improve the education of your students through increasing your knowledge, understanding, and effective use of ICT in education. As a preservice or inservice teacher, you know that ICT has been highly touted as a vehicle for improving education. Quite likely you do not know about the broad range of possible uses of ICT in education and the research (or, lack there of) that suggests these uses will improve education

There are certain aspects of improving education that can be mass-produced and/or mass distributed. That is, in some sense it is possible to apply ideas of automation to certain aspects of improving education. For example, we can work at a national level to develop better curriculum content and books that are designed to help students learn this curriculum content. Large numbers of such books can be printed and made available to large numbers of students. Similarly videos can be developed that combine curriculum content with some of our ideas on what constitutes effective instruction. Such videos can be distributed by broadcast and other methods in a manner that reach large numbers of students.

However, good teaching by humans currently lies at the very heart of good education for students. Good (human) teachers cannot be mass produced and/or mass distributed. As a preservice or inservice teacher, you have a responsibility of becoming as good a teacher as you can be. Moving up the "good teacher" expertise scale is a lifelong activity. The progress that you make will contribute to improving the education of your students.

Activities for Chapter 0

The activities here and at the end of other chapters are mainly designed to guide you in reflective consideration of the chapter. They are an integral component of the content of the chapter. Spend a few minutes thinking about the questions—even if they are not required assignments. Remember, education should not be a battle between students and their teachers. You are an adult, and you should be able to take responsibility for your own learning.

1. Now that you have read this chapter, "off the top of your head" name one idea covered in the chapter that seems particularly relevant to you, and name one idea that seems of relatively less relevance to you. Compare and contrast these two ideas from your point of view, explaining why one is of greater relevance (to you) than the other. Note that this type of question has lower-order and higher-order components. The first part of the question is lower-order. It asks you to select and name two ideas from the chapter. The second part of the question is higher-order. It asks you to do some compare and contrast thinking and presentation of logical or emotional arguments.

2. Consider your current level of expertise as a preservice or inservice teacher. What is one of your specific areas of relatively high expertise? (This is a lower-order question, but answering it requires some understanding of the job of being a teacher and the idea of expertise in being a teacher.) Then share your current understanding of how ICT is affecting and/or might soon affect this specific area of your knowledge and skills. (This is a higher-order question). The overall design of this activity is based on the ideas of constructivism—encouraging you to understand and then build upon your current knowledge and skills.

Chapter 1

Foundational Material

"They know enough who know how to learn." (Henry Adams)

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

This book is about Information and Communication Technology (ICT) in education. Here are two key, unifying ideas:

1. A new technology such as ICT is developed as an aid to helping to solve certain types of problems that people deem to be important. Education was not the driving problem that led to the development of ICT. However, ICT has proven to be a powerful aid in addressing a wide range of problems in education and in many other fields.

2. A new technology creates problems. First, there are the problems of change, as old ways of addressing certain problems give way to new ways to address the same problems. Second, the new technology facilitates the identification of old and new problems that can make effective use of the technology. Many of these are problems that could not and cannot be effectively addressed by older technologies. In terms of our educational system, ICT is the basis of many problems in curriculum content, teaching processes, assessment, and teacher education.

A Big "Big Idea"

The diagram of Figure 1.1 illustrates the single most important idea in this book. The idea is that properly educated people, using tools that aid their physical bodies and their minds, can solve a wide variety of challenging problems and accomplish a wide variety of challenging tasks. Such tools empower us to do things we cannot do without the tools.
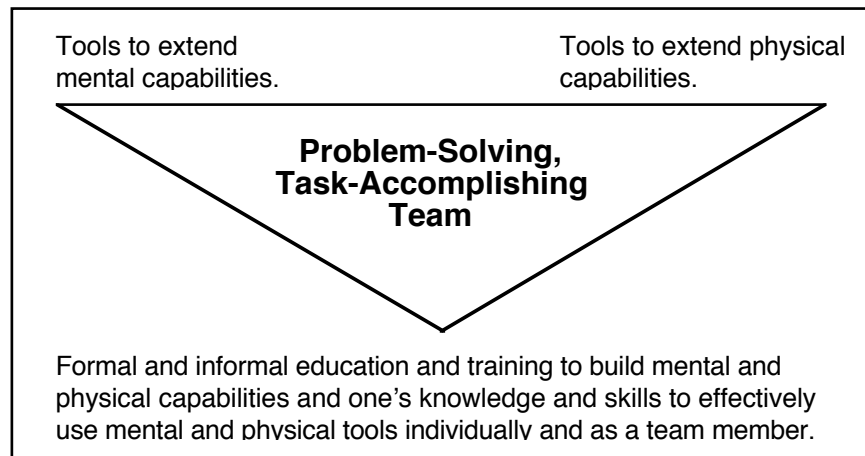

Figure 1.1. Problem-solving, task-accomplishing team.

Some examples of mental tools (often called mind tools) include reading and writing, arithmetic and mathematics, and ICT. And, of course, you know that ICT plays a major role in

the field of tools that extend people's physical capabilities such as robots used in factory automation.

Researchers and inventors are continually adding to our collection of mind and body tools. This means that our formal and informal education and training systems are faced by an ongoing and continually growing challenge. Over the past century, the pace of growth of human mind and body tools has accelerated. Our formal educational system has responded by providing (indeed, requiring) more and more years of formal schooling. There has been a huge growth in enrollment in higher education programs of study.

Our educational system has made a lot of progress in the past century. However, it is evident that the pace of growth of the "totality of human knowledge," mind tools, and body tools far exceeds the pace of improvement in our formal education system. For example, there are a variety of published estimates on the growth of human knowledge, and they tend to suggest that a doubling is occurring every five to ten years, or even faster (How Much Information, 2003).

The invention or development of a new physical body or mental tool creates both opportunities and challenges. In brief summary, a new tool:

1. Helps us to "better" solve some problems and accomplish some existing tasks that we are currently addressing without the new tool. Here, the term "better" may have meanings such as: in a more cost effective manner; faster; more precisely; with less danger; and so on.

2. Helps us to solve some problems and accomplish some tasks that cannot be solved without the tool, and helps us to identify new problems and tasks that require use of the new tools.

3. Creates new problems. ICT in education, for example, creates problems such as digital equity, the need for a relatively expensive addition to a school's infrastructure, and how to provide appropriate ICT education for preservice and inservice teachers. IT in education creates problems of how to deal with potential changes in curriculum content, instructional processes, and assessment in a manner that leads to students getting a better education.

ICT in Teaching and Learning

Our formal education system has a 5,000-year history, dating back to the development of reading, writing, and arithmetic (Divitt et al.). Over this period of time, educators have been faced by problems such as:

• What is appropriate content to include in the students' curriculum?

• What are effective instructional practices for helping students to learn the curriculum content?

• What are effective student assessment practices to support student learning and school system accountability?

• What are effective preservice and inservice teacher education programs of study that lead to students having effective (good) teachers?

It is evident that answers to these questions change over time. Answers are strongly affected by increases in human knowledge. In this book we are specifically interested in how the answers

are being affected by the developments that are occurring in ICT. Thus we are led to four specific ICT in education questions:

• What is appropriate ICT content to include in the students' curriculum?

• What are effective uses of ICT for helping students to learn the non-ICT and the ICT curriculum content?

• What are effective uses of ICT in student assessment in non-ICT areas, and what are other effective ways to assess student ICT knowledge and skills?

• What are effective preservice and inservice teacher education practices that lead to effective integration of ICT into curriculum content, instructional processes, assessment, and teacher's overall professional learning and work?

These are hard questions. Moreover, ICT continues to change at a very rapid pace. Thus, answers to the questions are changing and will continue to change in the future.

This issues raised in these questions are a challenge to our PreK-12 and teacher education system. It is a major challenge to both preservice and inservice teachers. The rapid pace of change in ICT is continually outdating their ICT knowledge and skills.

Brain and Mind Science

We now have 5,000 years of accumulated knowledge about teaching and learning in school environments. This knowledge is called the Craft and Science of Teaching and Learning. Part of the progress in the Craft and Science of Teaching and Learning falls into the area called Brain and Mind Science. The remainder of this section gives a brief introduction to that field. Chapter 0 provides one example of such progress in its discussion of dyslexia. The next major section of the current chapter contains more information about the Science of Teaching and Learning.

Continuing research on the science of the mind (psychology), recent research on the science of the brain (neuroscience), and rapid continuing progress in ICT are making significant contributions to the field of problem solving in all disciplines. The following three sub sections contain three Big Ideas emerging from this progress.

Brain Versus Computer

In the early days of computers, people often referred to such machines as *electronic brains*. Even now, more than 50 years later, many people still use this term. Certainly a human brain and a computer have some characteristics in common. However:

• Computers are very good at carrying out tasks in a mechanical, "non-thinking" manner. They are millions of times as fast as humans in tasks such as doing arithmetic calculations or searching through millions of pages of text to find occurrences of a certain set of words. Moreover, they can do such tasks without making any errors.

• Human brains are very good at doing the thinking and orchestrating the processes required in many different very complex tasks such as carrying on a conversation with a person, reading for understanding, posing problems, and solving complex problems. Humans have minds and consciousness. A human's brain/mind capability for "meaningful understanding" is far beyond the capabilities of the most advanced computers we currently have.

Big Idea # 1: There are many things that computers can do much better than human brains, and there are many things that human brains can do much better than computers. Our educational system can be significantly improved by building on the relative strengths of brains and computers, and decreasing the emphasis on attempting to "train" students to compete with computers. We need to increase the focus on students learning to solve problems using the strengths of their brains and the strengths of ICT.

Chunks and Chunking

Here are three different types of human memory:

- Sensory memory stores data from one's senses, and for only a short time. For example, visual sensory memory stores an image for less than a second, and auditory sensory memory stores aural information for less than four seconds.

- Working memory (short-term memory) can store and actively process a small number of chunks. It retains these chunks for less than 20 seconds.

- Long-term memory has large capacity and stores information for a long time.

Research on short-term ("working") memory indicates that for most people the size of this memory is about 7 ± 2 chunks. This means, for example, that a typical person can read or hear a seven-digit telephone number and remember it long enough to key into a telephone keypad. When I was a child, my home phone number was the first two letters of the word diamond, followed by five digits. Thus, to remember the number (which I still do, to this day) I needed to remember only six chunks. But, I had to be able to decipher the first chunk, the word "diamond."

Long-term memory has a very large capacity, but this does not work like computer memory. Input to computer memory can be very rapid (for example, the equivalent of an entire book in a second), and can store such data letter perfect for a long period of time. The human brain can memorize large amount of poetry or other text. But, this is a long and slow process for most people. By dint of hard and sustained effort, an ordinary person can memorize nearly letter perfect the equivalent of a few books. However, the typical person is not very good at this. At the current time, the Web contains the equivalent of many millions of books.

On the other hand, the human brain is very good at learning meaningful chunks of information. Think about the chunks such as constructivism, multiplication, democracy, transfer of learning, and Mozart. Undoubtedly these chunks have different meanings to me than they do for you. As an example, for me, the chunk "multiplication" covers multiplication of positive and negative integers, fractions, decimal fractions, irrational numbers, complex numbers, functions (such as trigonometric and polynomial), matrices, and so on. My breadth and depth of meaning and understanding was developed through years of undergraduate and graduate work in mathematics.

It is useful to think of a chunk as a label or representation (perhaps a word, phrase, visual image, sound, smell, taste, or touch) and a pointer or index term that does two things:

1. It can be used by short-term memory in a conscious, thinking, problem-solving process.

2. It can be used to retrieve more detailed information from long-term memory.

Big Idea # 2: Our education system can be substantially improved by taking advantage of our steadily increasing understanding of how the mind/brain deals learns and then uses its learning in

problem solving. Chunking information to be learned and used is a powerful aid to learning and problem solving.

Augmentation to Brain/Mind

In essence, reading and writing provide an augmentation to short-term and long-term memory for personal use and that can be shared with others. Data and information can be stored and retrieved with great fidelity.

The strongest memory is not as strong as the weakest ink. (Confucius, 551-479 B.C.)

Writing onto paper provides a passive storage of data and information. The "using" of such data and information is done by a human's brain/mind.

Computers add a new dimension to the storage and retrieval of data and information. Computers can process (carry out operations on) data and information. Thus, one can think of a computer as a more powerful augmentation to brain/mind than is provided by static storage on paper or other hardcopy medium.

Big Idea # 3: ICT provides a type of augmentation to one's brain/mind. The power, capability, and value of this type of augmentation continue to grow rapidly. Certainly this is one of the most important ideas in education at the current time.

Four Important Components of the Science of Teaching and Learning

The Science of Teaching and Learning (SoTL) has made great progress in recent years. Bransford et al. (1999), a book that is available free on the Web, provides an excellent overview of SoTL. I strongly recommend that all preservice and inservice teachers read the first chapter as an introduction to this important field of study.

In this section of Chapter 1 we provide brief introductions to four important components of SoTL: constructivism, situated learning, motivation, and transfer of learning. Each of these is important to all teachers and all students at all grade levels and in all academic disciplines.

Constructivism

Constructivism is a learning theory that says a learner constructs new knowledge and understanding on top of and integrated with his or her current knowledge and understanding. Constructivist learning is based on the participant's active engagement in critical thinking, problem solving, search for meaning and understanding, and metacognition.

The basic ideas of constructivism date back at least a hundred years, with much of this early work being done by John Dewey (1859-1952). The early research has been solidified by more recent research by Jerome Bruner and many others (Ryder, n.d.).

The President's Council of Advisors on Science and Technology (PCAST, 1997) report summarizes the research literature on computers in education up through 1996. It includes a strong focus on constructivism as the most important underlying learning theory in the field. Quoting Section 4.2 of the report:

Constructivist theory has given rise to an approach to educational practice that places the locus of initiative and control largely within the student, who typically undertakes substantial, "authentic" tasks, presented in a realistic context, that require the self-directed application of various sorts of knowledge and skills for their successful execution. Such activities often involve student-initiated inquiries driven at least in part by the student's own curiosity, and are designed to motivate students in a more immediate way than is typical of traditional curricula based largely on the transmission of isolated facts.

> Constructivist curricula often emphasize group activities designed in part to facilitate the acquisition of collaborative skills of the sort that are often required within contemporary work environments. Such group activities may offer students of varying ages and ability levels, and having different interests and prior experience, the opportunity to teach each other -- a mode of interaction that has been found to offer significant benefits to both tutor and tutee. Explicit attention is also given to the cultivation of higher-order thinking skills, including "meta-level" learning -- the acquisition of knowledge about how to learn, and how to recognize and "debug" faulty mental models.

Those of you who are familiar with project-based learning will see a strong parallel between PBL and the above discussion of constructivism. At the current time, this book does not contain a chapter on ICT-Assisted PBL. In lieu of this, I maintain a Website on that topic (Moursund, PBL Website, n.d.). That Website contains a detailed syllabus for a one-credit course on ICT-Assisted PBL, most of the reading material needed for such a course, and a large annotated bibliography. I strongly recommend that instruction on this topic be included in the same course where the book you are currently reading is being used.

Situated Learning

A learning theory called Situated Learning has been developing over the past two decades. It focuses on the idea that much of what we learn is dependent on the specific situation (environment, context) in which the learning occurs. Situated Learning emphasizes learning by doing and learning by addressing real, challenging problems.

ICT is a powerful aid to "doing" and to "addressing real, challenging problems." Thus, Situated Learning and ICT work well together. Situated Learning and Constructivism are compatible and mutually supportive.

Greg Kearsley maintains a Website that discusses a large number of different learning theories (Kearsley, n.d.). Quoting Kearsley:

> [Jean] Lave argues that learning as it normally occurs is a function of the activity, context and culture in which it occurs (i.e., it is situated). This contrasts with most classroom learning activities which involve knowledge which is abstract and out of context. Social interaction is a critical component of situated learning -- learners become involved in a "community of practice" which embodies certain beliefs and behaviors to be acquired. As the beginner or newcomer moves from the periphery of this community to its center, they become more active and engaged within the culture and hence assume the role of expert or old-timer. Furthermore, situated learning is usually unintentional rather than deliberate. These ideas are what Lave & Wenger (1991) call the process of "legitimate peripheral participation."

Nowadays, the majority of adults in the United States (and, in many other countries) routinely make use of computers (email and the Web), cell telephones, CD and DVD players, and a large number of ICT systems that are built into cars, TV sets, and so on. By the end of 1999, the number of computers being used in the "white collar" sector of business and industry in the US exceeded the number of workers in this sector. That is, the ratio of computers to workers exceeded 1.0.

This situation is in stark contrast with student use of ICT in PreK-12 schools. Schools in the US have an average of about one microcomputer per four to five students. Although more than half of these microcomputers are now located in classrooms (as contrasted with computer labs), their use is not routinely integrated into everyday student work. A significant fraction of the available ICT resources are used for playing games or using edutainment software that has questionable educational value. It is common for students in elementary schools to be scheduled into a computer lab for about 40-50 minutes, one or twice a week. The instruction in the lab and the work done there is often not integrated with their routine classroom work. Viewed from a Situated Learning perspective, the general types of uses of ICT in school are relatively far

removed from the general goals for our educational system as well as from the goals for ICT in education that have been set by many states and by the International Society for Technology in Education (ISTE NETS, n.d.).

Motivation

A newborn child's brain is designed to learn, is naturally curious, and is intrinsically (internally) motivated to learn. If the child is provided with an environment that is reasonably conducive to and supportive of learning, learning will occur at a rapid pace. This learning will include the marvelous accomplishment of learning to speak and to understand speech, and learning the culture of his or her environment. A child raised in a bilingual, bicultural environment will become fluent in two languages and will become bicultural. This speaks to a child's learning potential, and to the fact that our informal and formal educational system is not doing well in helping children achieve their learning potentials.

You are familiar with many different forms of extrinsic motivation, perhaps based on a system of rewards and/or punishments. Likely you are familiar with B.F. Skinner's theory of behaviorism. Through appropriate use of behaviorist principles, rats, cats, dogs, people, and other animals can be trained to elicit certain predefined behaviors. These stimulus/response types of training have proven to be quite effective. Note, however, in terms of education of humans, behavioral learning theory has largely given way to a variety of cognitive learning theories.

There is no fine dividing line between intrinsic and extrinsic motivation. For example, consider a child growing up in the environment/culture of the home and community that includes the routine playing of musical instruments and enjoyment of music. Howard Gardner lists musical intelligence as one of the eight innate intelligences that people have (Gardner, n.d.). One can argue that each person has a certain level of intrinsic motivation to learn and do music. Growing up in a musically rich environment/culture provides a type of extrinsic motivation that blends with a child's intrinsic music motivation. Eventually the child may develop a high level of intrinsic motivation in the field of music, and he or she may pursue a professional career in this field.

The music example illustrates a key idea in education. Teachers face the task of helping their students to become intrinsically motivated. Students who are intrinsically motivated (inherently interested) in a particular learning task will tend to learn more, better, faster, and remember longer what they have learned. Contrast this with a student who is extrinsically motivated to pass an upcoming test. The motivation may be to avoid failing a course, to get a good grade in a course, to please the teacher or parents, to get a money reward from parents, and so on. By and large this extrinsic type of motivation leads to a "memorize, regurgitate, and quickly forget" type of learning.

During my lifetime, I had the pleasure of watching my children and some of my grandchildren grow up in ICT-rich home environments. For many children, interactive computer games and other aspects of ICT are highly attention grabbing and seem be intrinsically motivating. When given an appropriate supportive environment, many children become intrinsically motivated to learn and routinely use ICT for play and work.

Over the years a number of "productivity" software tools have been that many people find to be intrinsically motivating. Perhaps the first example was the spreadsheet. Approximately a half million people acquired Apple 2e computers and this software because it fit so well with what they wanted to do. A number of other intrinsically motivating pieces of tool software are discussed in Moursund (2000).

Transfer of Learning

Teaching for transfer is one of the seldom-specified but most important goals in education. We want students to gain knowledge and skills that they can use both in school and outside of school, immediately and in the future. The article abstract quoted below serves to define two major theories about transfer of learning (Perkins and Solomon, 1992).

> **Transfer** of learning occurs when learning in one context enhances (positive transfer) or undermines (negative transfer) a related performance in another context. Transfer includes **near transfer** (to closely related contexts and performances) and **far transfer** (to rather different contexts and performances). Transfer is crucial to education, which generally aspires to impact on contexts quite different from the context of learning. Research on transfer argues that very often transfer does not occur, especially ``far'' transfer. However, sometimes far transfer does occur. Findings from various sources suggest that transfer happens by way of two rather different mechanisms. Reflexive or **low-road transfer** involves the triggering of well-practiced routines by stimulus conditions similar to those in the learning context. Mindful or **high-road transfer** involves deliberate effortful abstraction and a search for connections. Conventional educational practices often fail to establish the conditions either for reflexive or mindful transfer. However, education can be designed to honor these conditions and achieve transfer.

Transfer of learning is commonplace and often done without conscious thought. For example, suppose that when you were a child and learning to tie your shoes, all of your shoes had brown, cotton shoelaces. You mastered tying brown, cotton shoelaces. Then you got new shoes. The new shoes were a little bigger, and they had white, nylon shoe laces. The chances are that you had no trouble in transferring your shoe-tying skills to the new larger shoes with the different shoelaces. This is an example of reflexive, low-road transfer.

Similarly, suppose you have achieved a high level of automaticity (speed and accuracy) in keyboarding on a computer keyboard. Then you can easily transfer this knowledge and skill among different computer keyboards.

These examples give us some insight into one type of transfer of learning. Transfer occurs at a subconscious and reflexive level if one has achieved automaticity of that which is to be transferred, and if one is transferring this learning to a problem that is sufficiently similar to the original situation so that differences are handled at a subconscious level, perhaps aided by a little conscious thought.

You know that it can take a great deal of instruction and practice to achieve a high level of automaticity in keyboarding (or in many other areas, such as sight reading music and reading text). Thus, in your everyday life you routinely encounter problems and tasks where you have not achieved a high level of automaticity in solving the problem or accomplishing the task. This presents a challenge to you as a learner and to our educational system as a facilitator of learning. What can school do to help you learn to deal with novel problem situations?

Far transfer or high-road transfer present a major challenge to students and our educational system. Often our educational system and our students do poorly even when presented with very simple aspects of this challenge. For example, a secondary school math class might teach the metric system of units. Later in the day the students go to a science class. Frequently the science teacher reports that the students claim a complete lack of knowledge about the metric system. Essentially no transfer of metric system learning has occurred from the math class to the science class.

On a more general note, employers often complain that their newly hired employees have totally inadequate educations. Part of their complaint is that the employees cannot perform various tasks on the job that they "should have" learned to do while in school. Schools respond

by saying that the students have been taught to accomplish the tasks. Clearly, this is a transfer of learning problem that is owned jointly by schools, employees, and employers.

High-road transfer involves: cognitive understanding; purposeful and conscious analysis; mindfulness; and application of strategies that cut across disciplines. In high-road transfer, there is deliberate mindful abstraction of an idea that can transfer, and then conscious and deliberate application of the idea when faced by a problem where the idea may be useful.

For example, suppose that you are teaching your students to do process writing. Your students are leaning six steps:

1. brainstorming

2. organizing the brainstormed ideas

3. developing a draft

4. obtaining feedback from oneself and others

5. revising, which may involve going back to earlier steps

6. publishing—polishing the final product and making it available to others.

Can you think of problems other than writing in which this 6-step process, or a modification of it, might be applicable. How about composing music? How about painting a picture, designing a building, or choreographing a dance? How about doing a project in a project-based learning (Moursund, PBL Website, n.d.)?

If you are teaching for high-road transfer in this situation, you will teach your students that many different problems can be solved by use of a general Process Procedure that is illustrated by process writing. You will have your students learn the name of and a great deal about the Process Procedure in some specific area such as writing (the 6-step Writing Process). But, you will also have your students explore use of this Process Procedure in a number of different areas that are relevant to the students and to the goals of our educational system. (Examples are given in the previous paragraph.)

A number of other examples of teaching for high-road transfer are given in Moursund (2004). ICT plays an important role in the Process Procedure and in many other applications of high road transfer. In Process Writing, for example, ICT facilitates all six of the steps listed above. It is particularly useful in revision and in publishing.

Theory into Practice

There is a huge gap between our accumulated research knowledge in education and our actual school-based teaching and learning practices. To help you understand why this is the case, we will briefly discuss constructivism, situated learning, motivation, and transfer of learning from the point of view of a (hypothetical) reader of this book.

Constructivism

Here is a comment that might have been made by a student in one of my classes:

It is obvious to me that this course and its book are not specifically designed to meet my personal needs. The teacher and author do not know what I know and what I don't know about the general field of education or about ICT in education. Thus, much of the content is too easy, too hard, not relevant to me, and so on.(Hypothetical Reader)

Each student is unique. Each student learns by building (constructing) new knowledge on the top of (integrated with) current knowledge. Many students find that this task is frustrating because the instruction is not designed specifically for them.

You are probably familiar with the arguments that support small class sizes. Among other things, small class size supports more interaction between students and the teacher, and supports more individualism of the curriculum content, instructional process, and assessment. Indeed, research on the benefits of students having highly qualified personal tutors suggest that the typical average student in our school system is quite capable of learning as well as current students who are making A grades (Bloom, 1984).

It is possible to make a book highly interactive and to tailor it to a specific reader's needs. This is what is done in Highly Interactive Intelligent Computer-Assisted Learning (HIICAL). However, this is time consuming and expensive. It can easily cost millions of dollars to develop such a book or course. Thus, the development of such books/courses is usually done only in situations where there is a relatively large mass market or where there is large funding from a government agency or a private foundation.

Highly Interactive Intelligent Computer-Assisted Learning is a "natural" for many students with learning disabilities. For example, here is part of the abstract of paper by du Boulay and Luckin (2001):

> This paper reviews progress in understanding certain aspects of human expert teaching and in developing tutoring systems that implement those human teaching strategies and tactics. It concentrates particularly on how systems have dealt with student answers and how they have dealt with motivational issues, referring particularly to work carried out at Sussex: for example, on responding effectively to the student's motivational state, on contingent and Vygotskian inspired teaching strategies and on the plausibility problem. This latter is concerned with whether tactics that are effectively applied by human teachers can be as effective when embodied in machine teachers.

This means that in a typical teaching/learning situation in higher education much of the burden for constructivism lies with the individual learner. You (personally) know what you know. It is your job to take the learning materials and adopt them to your current knowledge and skills, and your specific needs. This is a very import idea for teachers. You can learn to be a "constructivist teacher." However, one of the most important things you can do is to help you students learn to be responsible, self-reliant, constructivist learners. This idea can be integrated into teaching beginning at the earliest grade levels, and then expanded upon year after year as students progress through school. It is part of the overall goal of helping students to become self-sufficient, lifelong learners.

Situated Learning: A Staff Development Example

Here is a comment that might have been made by an inservice teacher in one of my classes or workshops:

> I am an inservice teacher who is using your book in a workshop (short course) that I am taking. The workshop includes teachers who are interested in a number of different grade levels. The workshop is being given in a typical adult education setting, in an environment that is far removed from the one that I face in my teaching. It seems to me that this is a poor example of situated learning. (Hypothetical Reader)

I tend to agree with the Hypothetical Reader. As an inservice teacher, you want to use your new ICT knowledge and skills to work with PreK-12 students in classrooms where you teach. Certainly the adult education inservice or preservice teacher education workshop is quite a bit different than the environment in which you want to use the knowledge and skills that you are

gaining. Thus, you face a major problem in transfer of learning. As a teacher, one of my jobs is to help create conditions for high-road transfer of learning.

An effectively designed and facilitated preservice or inservice course/workshop can overcome some of the difficulties that named by the Hypothetical Reader. Here are some of ways in which this might be done:

1. The facilitator can draw heavily on the teaching knowledge and experience of the participants. This can be done in a manner that creates a discovery-based, highly interactive, sharing environment in which the participants gain a lot of "real classroom world" knowledge and skills.

2. All of the group discussions and all of the assignments or activities can be designed to allow participants to focus on ideas and examples specifically relevant to their own teaching situation.

3. Role-playing, or facilitator modeling of teaching to children, can be employed.

4. The specific situations that teachers will encounter in their schools and classrooms can be a major topic. Thus, participants can learn about how to make effective use of their new knowledge and skills in a one-computer classroom, in a class where most (or few) of the students have ICT at home, in a classroom that has a pod of five Internet-connected computers, in a computer lab, and so on.

5. All of the examples presented by the facilitator can be drawn from actual school classroom settings.

6. Participants can be provided with materials and access to materials that include detailed classroom lesson plans.

The above list can be expanded. However, all of the ideas are merely substitutes for a staff development approach that has proven very effective. It is a classroom demonstration in the learner's classroom. In this approach, a facilitator visits your classroom and teaches your students. You observe, perhaps acting as an assistant. Over time you gradually move from being an observer/helper to doing the instruction. For example, in an elementary school setting the workshop/course facilitator might do a writing lesson in which computers are used. You might then present a writing lesson later in the day or the next day, with the facilitator serving as your assistant and mentor. At a secondary school level the facilitator might teach one period, and you might then teach the same material using the same techniques in another section of the same course later in the day.

The trouble with this one-on-one approach is that it is quite expensive and does not lend itself to reaching the large number of preservice and inservice teachers who need the ICT education. Thus, this approach is most often found in schools that have an ICT coordinator whose duties include staff development. It can also be used in a school where the teachers each assume some of the staff development responsibilities in the school.

While the example of this section focuses on inservice teachers, the same ideas apply to preservice teacher education. Generally speaking, the "situation" of preservice education is quite different than the "situation" in which the preservice teacher will encounter on the job.

Motivation

Here are three comments that might have been made by students in one of my classes or workshops:

I have been told that I need to know more about ICT, and there are pressures "from above" (requirements) for me to learn more. However, the school where I teach and the classrooms that I have visited are not making much use of ICT. It is not clear to me that computers are improving the education of students—mainly they seem like a waste of time and money that might better be spent on essentials such as improving student learning of the 3 Rs. I don't have the time and energy to learn new things that are not immediately applicable to helping my students. (Hypothetical Reader # 1)

I have been routinely using computers and the Internet for years, and I think they are great. I think that all students should have easy access to ICT both in their classrooms and at home, and that they should make routine use of such facilities. I really enjoy learning more about ICT and then making use of my increasing knowledge and skills. (Hypothetical Reader #2)

I admit it, I am a computer junkie. I live and breathe computers. I probably spend half of my time using my computer system, playing computer games, browsing interesting sites, listing to radio stations on the Web, and so on. I like to have the newest and fasted hardware and connectivity. I like to learn new pieces of software, and I like to help other people learn about computers. (Hypothetical Reader #3)

Hypothetical Reader #1 has some extrinsic motivation. It may be that he or she is taking a required ICT course and doesn't particularly like computers.

Hypothetical Reader #2 has intrinsic motivation. As a preservice or inservice teacher you know that you will experience better teaching results when most are all of your students are intrinsically motivated to learn. However, the reality is that this situation is not easy to achieve and seldom occurs. Many of the participants in my workshops are not strongly intrinsically motivated to learn ICT and to apply their knowledge and skills in their teaching.

Hypothetical Reader #3 is almost passionate about computers. One might think of such passion as being a very powerful (perhaps overwhelming) intrinsic motivation.

Intrinsic motivation is a powerful aid to learning. Good teachers are good at helping students to discover and build intrinsic motivation and passion for various areas of learning.

It is assumed that you (a reader of this book) are an adult who has considerable intrinsic motivation to become or to be a good teacher. As an author, that makes my job easy. All I have to do is to help you understand the many benefits that ICT brings to students and teachers. If you become convinced that ICT can facilitate students getting a much better education, then it is likely that you will become intrinsically motivated to provide such ICT advantages to your students.

However, it is possible that no amount of evidence and arguments will convince you that calculators, computers, and Internet connectivity (email and the Web) are important to students in our educational system. If this is the case, here is something that might motivate you and help you develop intrinsic motivation as you read this book. Set a goal of becoming a highly qualified critic of ICT in education. Study ICT in education from the point of view of identifying its flaws and failing. I have developed a Web page to help you get started (Moursund, Arguments Against Website, n.d.).

Transfer of Learning

Here is a comment that might have been made by a student in one of my classes:

I think I understand the general concept of transfer of learning. However, I don't see how it applies to taking ideas from this book and using them with my students. This book seems far removed from my teaching environment. (Hypothetical Reader)

As noted earlier, the overarching mission of this book is to improve the education of our children. By reading about near/far transfer and about low-road/high road transfer, you have probably increased your knowledge about how to teach for transfer. Teaching for transfer is one of the most important ways to improve our educational system.

As also noted earlier, there is a huge gap between educational theory and educational practice. You need to carefully examine your teaching knowledge, skills, and practices. Here is some food for thought.

1. Does your curriculum include a lot of emphasis on students gaining a highly level of automaticity (speed and accuracy) in certain areas? Perhaps you can identify one specific area in which you are striving to develop "machine-like" capabilities in your students, but where machines such as calculators and computers are far faster and more accurate. Time spent in achieving the automaticity for near transfer or low-road transfer is time that is not available for teaching problem solving, critical thinking, and other higher cognition.

2. Do your students often take a "memorize and regurgitate" approach to materials you cover on your tests? Chances are that what they memorize and regurgitate is soon forgotten. There is almost no retention, or transfer into the future.

3. Many of the ideas and processes in problem solving, critical thinking and other higher-order cognition transfer over time and across different discipline areas. High road transfer provides a model for teaching for transfer, and it is especially relevant in teaching for problem solving, critical thinking, and higher-order cognition.

4. The chances are that your students have never been explicitly introduced to the idea of transfer of learning. Explore with your students their transfer of learning capabilities and limitations. Teach them the vocabulary *transfer of learning, low-road transfer,* and *high-road transfer,* and help them learn to identify when they are doing transfer of their learning.

As you read this book you will be exposed to many important educational ideas. Some will directly relate to ICT while others will apply to broader aspects of education. As you gain knowledge about one of these ideas, share it with some of your fellow preservice or inservice teachers, and with some of your students. Try out the ideas in your teaching. That is, try transferring your new knowledge into environment outside of the one in which you are reading this book.

Activities for Chapter 1
1. Do some reflective introspection about the intrinsic and extrinsic motivation that has led you to read this book. Make some mental notes about what you expect to get out of reading this book. Then think about what the Preface, Chapter 0, and Chapter 1 contribute toward these expectations, and whether they have added to your list of expectations.

2. Make a list of some of your important knowledge and skill low-road transfer areas. Analyze your list and how you gain these low-road transfer capabilities.

3. Make a list of some of your important knowledge and skill high-road transfer areas. Analyze your list and how you gain these high-road transfer capabilities

Chapter 2

Gaining Increased ICT in Education Expertise

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

"If you don't know where you are going, you're likely to end up somewhere else." (Dr. Laurence J. Peter, 1919-1990)

This book assumes that you have some introductory knowledge and skills in using an ICT system for word processing, email, and browsing the Web. For each of these tools, you have a level of ICT expertise that is useful to you. This expertise has likely come from some combination of formal instruction, learning from your peers, self-instruction that includes trial and error, and a lot of experience. You have some sense of your level of expertise relative to that of your peers, such as your fellow teachers or the members of your preservice cohort class.

This chapter explores the idea of expertise. While the specific target is expertise in the area of ICT in education, we will also look at expertise on a broader scale.

How a Discipline is Defined

You have some knowledge about a lot of different disciplines such as art, biology, chemistry, dentistry, economics, forestry, and so on. A discipline—a coherent area of human endeavor—can be analyzed from the point of view of:

- The types of problems, tasks, and activities it addresses.

- 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, language (including notation and special vocabulary), and methods of teaching, learning, and assessment.

- Its tools, methodologies, and types of evidence and arguments used in solving problems, accomplishing tasks, and recording and sharing accumulated results.

In this book we will think about disciplines in this way. We are particularly interested in how ICT has contributed to the problems that a wide variety of disciplines address, to the tools and methodologies that they use, and to the results that they have achieved.

For example, consider ICT in music. Some of the key aspects of music are composition, vocal and instrumental performance, and some combination of listening, appreciation, and criticism. You know, of course, that ICT now plays a major role in music distribution and that music piracy via the Web is a major issue. You also know about roles of computerized musical performance instruments and some roles of computers in composing (and producing written notation for) music.

ICT brings a new dimension to music education for relatively young children. Students can learn some of the rudiments of composition, and can compose music, before they have developed the skills to perform music on a "by hand" musical instrument. They can learn to use a computer system for both composition and performance.

Each discipline can be examined from the point of view of how ICT is contributing to the content of the disciplines—to the types of problems and tasks that it addresses. You undoubtedly know that computers and calculators have become integral components of math and the sciences. In the sciences, for example, there are now three major ways to explore, understand, and "do" a science. Typically these are labeled *theoretical, experimental,* and *computational.* In 1998, one of the winners of the Nobel Prize in chemistry received the award for his work in Computational Chemistry. This involved the development of and use of computer models of chemical processes. Computational astronomy, biology, chemistry, etc. are now all important components of their respective disciplines.

Computer modeling and use of computer models varies in importance from discipline to discipline. For example, it is really important in architecture, business engineering, economics, mathematics, and in all of the sciences. It is of less importance in art, the humanities, music, and a number of the social sciences.

Keep in mind that computer modeling is only one aspect of possible roles of ICT as part of the content of a discipline. Earlier in this section we briefly discussed some roles of ICT in music. In art, ICT provides a variety of new media. Computers have substantially changed the field of graphic arts. Similar comments hold for engineering drawing, where computer-aided design has emerged as a major component of the content area (CAD, n.d.).

Having Some Expertise vs. Being an Expert

There is a difference between having some level of expertise and being an expert. Within any domain or area of knowledge and skills that is under consideration, an expertise scale runs from a very low level to a very high level. From a teacher point of view, you want to help your students move up expertise scales that correspond to the areas that you teach. Here are a few things to be aware of:

1. A learner brings existing knowledge and skills to whatever new learning task they face. This situation is the core of constructivism.

2. Learners vary in their innate mental and physical capabilities. Note, however, that the "nature versus nurture" issue is very complex. As teachers, our goal is to help our students to develop knowledge and skills that move them up various expertise scales. Some students will move up faster and have the potential to move up further than other students.

3. It is very difficult (indeed, for the most part it is impossible) to accurately predict a long time in advance either how fast a learner will move up a particular expertise scale or how far along the scale the learner might progress. One of the things that educators have learned is that setting high goals and standards is usually very desirable. But, this must be done using common sense. Most children will not become world-class athletes or world-renowned research professors.

4. Expertise in a domain has many dimensions. Some of these dimensions, such as drive, persistence, and motivation tend to cut across many different areas of expertise. There is considerable transfer of learning between areas of expertise. However, a high level of expertise in a domain requires a high level of knowledge within the domain.

5. Increasing expertise draws upon gaining an appropriate combination of experience, and lower-order and higher-order knowledge and skills. While lower-order and higher-order can be taught and practiced somewhat separately from each other, seamless integration is

a goal. Educational research and practice suggests that this integration should be inherent to the teaching and learning process.

6. A high level of expertise in a domain is exemplified by high knowledge and skill that is efficiently and effectively applied to solving the problems and accomplishing the tasks of the domain. Rote memory, no matter how good one's memory, is of limited value in achieving a high level of expertise in a domain.

As an example of some of the above ideas, consider helping a student to gain increased expertise in writing in a word processing environment. This is obviously a complex domain, since it includes writing, word processing, and desktop publication, each of which is a complex domain. Thus, to move a student up this expertise scale we might:

1. Place most of our emphasis on improving the learner's writing knowledge and skills.

2. Place most of our emphasis on improving the learner's word processing knowledge and skills. This might include learning fast keyboarding and/or learning to make effective use of voice input. It might also include learning to compose and edit at a keyboard.

3. Place most of our emphasis on improving the learner's desktop publication knowledge and skills. This might include learning page design and layout, and effective use of graphics.

4. Seek a middle position that combines aspects of 1-3 in a manner that best contributes to helping the student move up the expertise scale. This "middle" position will vary from student to student.

We know that spelling, grammar, and writing legible (good penmanship) are all important aspects of (1). However, in some sense these are lower-order aspects as contrasted with developing and representing ideas that communicate effectively. Also, we know that a word processor is a powerful aid to spelling and legibility, and it is also a useful aid in grammar. It is a powerful aid to layout and design for effective communication. Thus, it might prove desirable to place less emphasis in (1) on spelling and legibility, and perhaps less time on grammar (especially in the areas that a computer can do well). This frees up time for more emphasis on higher-order aspects of writing and time for learning to use a word processor. Some of the time might be used to help students gain increased knowledge and skills in process writing and in process writing in a word processing environment.

Nowadays, the trend is toward seeking a position somewhere between the extremes expressed in 1-3. We know, of course, that constructivism and individualization are important. The approaches 2 and 3 provide an extra challenge to our educational system since students vary widely in their computer background and experience, and in their access to computers.

Exploring ICT Aspects of a Teacher's Expertise
You are intrinsically and extrinsically motivated to be a good teacher. As a preservice or inservice teacher, you are faced by the challenge of gaining an appropriate level of expertise in teaching the various disciplines you teach. What constitutes an appropriate level of expertise? This is not an easy question to answer. Research tells us that the effectiveness of a teacher depends on a number of different things, such as the six listed below.

• curriculum; content knowledge of the disciplines being taught

• pedagogy; knowledge and skill in teaching the disciplines

- assessment; knowledge and skill in assessment

- classroom management knowledge and skills

- general communication skills

- continued professional growth; being a lifelong learner

ICT is now part of the content of each discipline that you teach or are preparing to teach. ICT is an aid to teaching any discipline, and ICT is an aid to assessment in any discipline. ICT tends to be an added classroom management burden, whether computers are located in your classroom or you take your students to a computer lab. ICT is a useful aid to communication with parents, your fellow educators, and your students. ICT provides a number of aids to learning, both for teachers and for their students. In brief summary, ICT is now a significant component of many different aspects of one's expertise as a teacher.

Let's explore your knowledge and skill in word processing and desktop publication using a word processor. Is your word processing and desktop publication level of expertise adequate to the demands that you, your students, your school, and other aspects of your professional life might place on it?

One way to answer such a question is through self-assessment. Take a look at the self-assessment instrument illustrated in Figure 2.1. Use this scale to assess your word processing and desktop publication expertise in the three areas: content, pedagogy, and assessment.
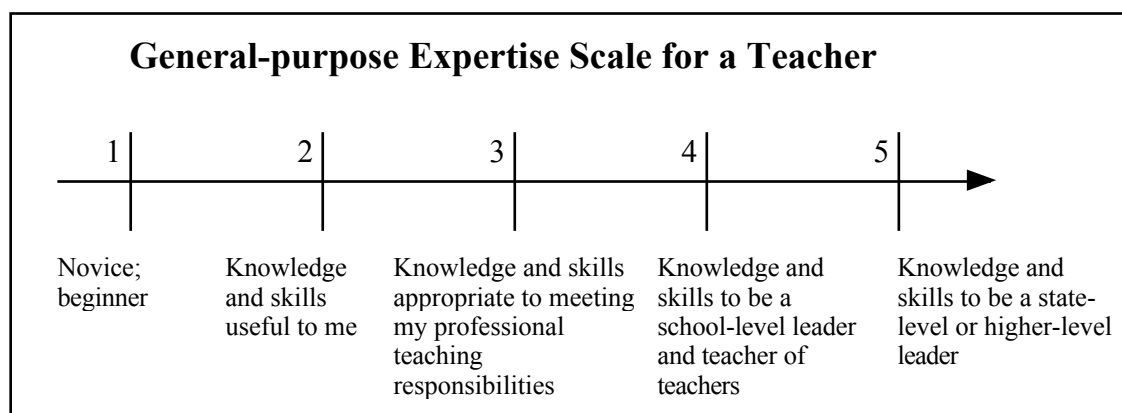
Figure 2.1. General-purpose expertise scale for a preservice or inservice teacher.

Presumably you would like to be able to say that you are a "3" or higher on each of these three areas. But, how do you know? Do you know what the professional teaching responsibilities are or might soon be in each of these three areas?

To make this situation still more complex, there are many different computer tools that students are using or might be using in schools. Chapter 4 of this book lists a number of ICT generic tools—tools that cut across many disciplines. Chapter 5 discusses some non-generic ICT tools as well as ICT content that is now an important part of the content of various disciplines.

Some help is available through the International Society for Technology in Education (ISTE), a non-profit professional society that specifically focuses on ICT in precollege education and in teacher education. ISTE has developed National Educational Technology Standards (NETS) for students, teachers, and school administrators (ISTE NETS, n.d.).

In very brief summary, the ISTE NETS for teachers states that a teacher at the precollege level should meet the ISTE NETS for students graduating from the 12th grade and should meet a comprehensive set of ICT requirements that are specific to the profession of being a teacher.

The ISTE NETS for precollege students are organized into six general categories. (ISTE NETS).

1. Basic operations and concepts

2. Social, ethical, and human issues

3. Technology productivity tools

4. Technology communications tools

5. Technology research tools

6. Technology problem-solving and decision-making tools

Thus, you can look at this list and see if it helps you to understand your current levels of expertise in use of a word processor and in doing desktop publication using a word processor. However, as you try to do this you will likely decide that you need still more information, because this list is too general.

ISTE provides some additional detail in sets of benchmarks for students completing various grade levels. The 5th grade standards listed below are quoted below (ISTE NETS, n.d.). The numbers in parentheses at the end of each standard are from the list of general categories 1-6 given above.

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. (1)

2. Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide. (1, 2)

3. Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use. (2)

4. Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum. (3)

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. (3, 4)

6. Use telecommunications efficiently to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests. (4)

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. (4, 5)

8. Use technology resources (e.g., calculators, data collection probes, videos, educational software) for problem solving, self-directed learning, and extended learning activities. (5, 6)

9. Determine which technology is useful and select the appropriate tool(s) and technology resources to address a variety of tasks and problems. (5, 6)

10. Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources. (6)

The chances are that you find this list of 5th grade student standards somewhat helpful and somewhat intimidating. They do not provide enough detail for you to adequately self-assess your

word processing and desktop publication knowledge and skills. However, they suggest that word processing is only a small part of what a teacher needs to know about ICT in education.

Remember, ISTE recommends that all teachers meet the 12th grade standards for students! Perhaps you do not yet satisfy the list of knowledge and skills given in #5 that are applicable to word processing and the Web. Also, you might conclude that you need still more detailed information to appropriately self-assess yourself using the scale in Figure 2.1.

To continue in our self-assessment task, lets look more closely at word processing and desktop publication. Here are three paragraphs that summarize some of the key ideas in word processing and desktop publication in a word processing environment:

1. A modern word processor contains hundreds of aids to writing and editing. For example, it may contain aids to help create headers, footers, page numbering, tables, styles, index, and table of contents. It may contain an outliner, 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. In 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.

2. Desktop publishing is the design and layout of a hardcopy document for effective communication. Increasing expertise is shown by knowing and following the rules about choices of typefaces, effective use of white space, design, layout, Z scan, graphics, and color to improve communication. It is also shown by knowing how to design and use "styles" (the style sheet facilities of the word processor).

3. Research in writing suggests that a six-step approach, called Process Writing, is a good approach to writing. Perhaps the single most important step is "revise, revise, revise," and a word processor is particularly useful in this step However, a word processor is an important aid in all of the steps.

These three paragraphs have the "flavor" of a word processor as being a tool to be used in creating and publishing hardcopy documents that communicate effectively. The software provides many aids. The underlying theory of design, layout, typefaces, and so on contributes substantially to effective communication. Research supports the value of learning to make effective use of a word processor as an aid to increasing expertise as a writer (Goldberg, 2003).

Finally, you will note that even at this level of detail, we have not mentioned any particular piece of word processing software or any particular hardware platform. We have not discussed speed and accuracy in keyboarding. We have not discussed use of software for outlining. We have not discussed how one teaches a student to make effective use of a word processor in writing. In short, we have made progress, but we still have a long way to go.

Let me summarize the situation we are exploring. You are used to the idea of "writing in the content area" and that every teacher has responsibility for helping students gain increased writing skill. Word processing and desktop publication are part of the overall field of writing. As word processing and desktop publication become more and more thoroughly integrated into the everyday school curriculum, you will be faced by increasing responsibility for helping your students get better at use of these tools and ideas in the writing that they do.

Further Considerations About Word Processing

One of the intriguing aspects of ICT tools is that a person can gain a useful level of knowledge and skill in a modest number of minutes. However, each ICT tool is useful as an aid to problem solving and accomplishing a variety of higher-order, challenging tasks. Thus, moving up the expertise scale in use of a particular tool requires a combination of learning to use the tool better and learning to use the tool to solve complex problems and accomplish complex tasks.

This provides a strong argument for the routine integration of ICT into each subject area that students study.

However, such integration presents major challenge to our educational system. As an example, consider word processing. A word processor is a useful aid to process writing. With appropriate instruction and practice, relatively young students can learn to keyboard much faster than they can print or handwrite, and the keyboarding provides much more legible text. Thus, a school might decide that its students should learn word processing as part of the overall process of learning process writing and learning to communicate effectively in writing. Now consider questions such as the following:

1. At what grade level or age is it appropriate for a student to begin to learn to use a word processor?

2. What should be dropped from the curriculum in order to make time for a student to learn to effectively use a word processor? Alternatively, is there good evidence that knowing how to effectively use a word processor will save the student more time than it takes to gain such knowledge and skill?

3. Who should provide the needed instruction? (What are the desirable qualifications? Remember, a word processor is not a typewriter. A person who is skilled at teaching typing may know little about word processing and teaching a student to write in a word processing environment).

4. How much school time should be used in helping a student to become fast and accurate at key boarding? (And, or course, at what age or grade level should this be done, and what should be dropped from the curriculum to provide the needed time?)

5. As a student gains skill in using a word processor (including the spelling checker and other built-in aids to writing), should the student be allowed to (or, required to) make use of this facility in writing and in taking essay tests?

6. Is use of a basal spelling text and weekly or more frequent "by hand" spelling test an effective and appropriate part of the curriculum when students routinely write using a word processor with a built-in spelling checker?

7. How should a teacher deal with the fact that some students have access to a word processor and other electronic aids to writing at home, and some do not?

8. Should cursive writing be dropped from the curriculum?

These types of questions help to suggest some of the breadth and depth challenges that teachers and schools face as they move toward greater integration of word processing into the everyday classroom. Somewhat similar challenges greet widespread adoption of other computer tools into the curriculum.

Final Remarks

There are many general-purpose ICT tools that students can learn to use as they progress through PreK-12 education. Chapter 4 on Generic Tools discusses some of these. The ISTE NETS for students do not provide details on what students could or should learn over this full range of widely used, general-purpose ICT tools. However, the "message" in these student standards and in the ISTE NETS for teachers is clear. A wide range of Generic Tools are now important to students at the PreK-12 level, and teachers need to be able to work effectively with students who use these tools and/or are learning to use these tools.

Each of the Generic ICT Tools has the characteristic that a very modest amount of knowledge and skill is useful to the learner. However, each is a powerful aid to higher-order thinking and problem solving. At the current time, our educational system is doing a relatively poor job of moving students up the ICT expertise scale, toward using ICT as a routine aid to solving complex problems and accomplishing complex tasks.

This chapter has given you some insight into roles and issues of a word processor (and its accompanying desktop publication tool) as an aid to student written communication. This same type of moderately deep analysis can be done for each of the general-purpose ICT tools that are relevant to solving the problems and accomplishing the tasks within the core curriculum areas taught at the PreK-12 levels. You, as a preservice or inservice teacher, are faced by the challenge of gaining appropriate levels of expertise within these ICT tool.

The next few chapters address some of the topics of various aspects of ICT in education in which all teachers need to have a reasonable level of expertise.

Activities for Chapter 2

1. This chapter explored word processing and desktop publication—one of the prerequisite knowledge and skill areas assumed in this book. Select one of the two other prerequisite areas—email or the Web—and analyze it at the same level of depth that this chapter applied to word processing and desktop publication. As you do this analysis, reflect on the level of knowledge and skill you need in this ICT area to facilitate your students moving up the "knowledge, skills, and experienced user" expertise scale in this ICT area.

2. As a preservice or inservice teacher, you have varying levels of expertise in various aspects of what it takes to be a highly effective teacher. Think about your teaching-oriented, but not ICT-oriented, area of greatest expertise. Analyze it from multiple points of view, such as your level of expertise relative to other teachers, your level of expertise relative to your teaching needs, how you gained your current level of expertise, what you are doing to maintain or increase your current level of expertise, critical components that contribute to your current high level of expertise, and so on.

3. This chapter briefly discussed the idea of writing across the curriculum and tied it in with word processing and desktop publication across the curriculum. Select some other student knowledge and skill area. Analyze it from the point of view of whether it should be an "across the curriculum" area and the aspects of ICT that lie within that area. (Doing library research as an aid to solving a problem or accomplishing a task provides a good example. Use this one as a last resort if you cannot think of any other.)

Chapter 3

Compelling and Second Order Applications

"The real problem is not whether machines think but whether people do." (B.F. Skinner, 1969)

"You don't just learn knowledge; you have to create it. Get in the driver's seat, don't just be a passenger. You have to contribute to it or you don't understand it." (Dr. W. Edwards Deming)

By now you have begun to appreciate some of the challenges that ICT brings to education. You may have begun to form some definite opinions on appropriate goals for ICT in our formal educational system. You may have developed some ideas as to what should be added to the curriculum, and what should be deleted.

This chapter explores two important ideas about ICT in education:

1. Some computer applications are intrinsically motivating and have been widely adopted because of this and their value to users. We call them **Compelling Applications.**

2. Much of the ICT use in our schools is at a relatively low level that we call **First Order.** ICT will begin to have a much greater impact on education as we move toward **Second Order** applications.

A Little Bit of History

The "mass production" of electronic digital computers began in 1951, with the Introduction of the UNIVAC I. These early computers were expensive and not terribly reliable. However, they were a valuable aid to solving problems and accomplishing tasks in business, government, military, and research. During the 1950s, some colleges and universities acquired computers and developed courses on their use. By 1958, there were already some precollege students who were learning how to write computer programs in machine language or in FORTRAN, a science-oriented programming language.

Note: There are a huge number of Websites that focus on computer history. My recent Google search using the term *computer history* and then a second search using the term *history of computers* each reported more than 20 million hits. If this topic interests you, be sure to take a look at the Charles Babbage Institute at http://www.cbi.umn.edu/.

The computer industry grew rapidly, as did the capabilities of computers. The 1960s saw the development of local area computer networks and time-shared computing. The trend was to make computers more readily available to people and more convenient to use. While the development and sales of "large, expensive" mainframe computers continued at a remarkable pace, less expensive and smaller minicomputers were developed. It became common for scientists to have minicomputers in their laboratories.

The latter half of the 1970s saw the development of microcomputers. In the first few years, a number of companies produced a variety of microcomputers. The Apple 1 was produced in 1976, and various versions of the Apple 2 had been in production for years before IBM developed and began selling its first microcomputer in 1981. In the year 2004, the worldwide sales of

microcomputers were approximately 175 million machines, or about one per 35 people on earth. It is interesting to contemplate the fact that today's modestly priced microcomputer is hundreds of times as fast as the million dollar mainframes of the early 1970s. Measured just in terms of compute power, current annual production of microcomputers is more than equivalent to one circa 1970 mainframe computer for each person on earth.

Compelling Applications

There are a number of computer applications that are compelling (intrinsically motivating) to people, companies, government agencies, and so on. The following article discusses the idea of compelling computer applications that many students and educations find to be intrinsically motivating.

Roles of IT in Improving Our Educational System

Moursund, D.G. (October 2000). Roles of IT in Improving Our Educational System. Part 2: Compelling Applications. *Learning and Leading with Technology*. Eugene, OR: ISTE. Reprinted with permission from *Learning and Leading with Technology* (c) 2000-2001, ISTE (the International Society for Technology in Education. 800.336.5191 (U.S. & Canada) or 541.302.3777, cust_svc@iste.org, http://www.iste.org/. Reprint permission does not constitute an endorsement by ISTE of the product, training, or course.

When microcomputers first started to become popular in the late 1970s, most computer-using businesspeople viewed them with disdain. Microcomputers were underpowered and not particularly useful in solving the problems and accomplishing the types of tasks businesspeople faced. Instead, microcomputers were "toys" that might best be used to play games or solve inconsequential problems.

This attitude toward microcomputers was forever changed with the 1979 development of the first spreadsheet software. A spreadsheet running on a "toy" computer was a powerful aid to doing bookkeeping and accounting tasks. Moreover, the software made it relatively easy to incorporate formulas (for example, compound interest and payment schedules) to help solve a particular problem. Thus, the spreadsheet software could handle many of the types of real-world problems faced by businesspeople.

The spreadsheet had an additional feature, one that made it particularly compelling. A spreadsheet can be viewed as a type of mathematical model for a particular aspect of a business (such as payroll or inventory). With this computerized mathematical model, it is easy to ask "what if?" questions and get prompt answers.

Compelling Applications (Two Examples and an Overview)

Spreadsheet. From the point of view of businesspeople, the spreadsheet was the first compelling application of a microcomputer. For this particular group of people, spreadsheet software has the following characteristics:

1. It is intrinsically motivating. (The user is intrinsically motivated to learn to use the software, because it is such a powerful aid to doing his or her job.) It empowers the user to solve problems and accomplish tasks that the user cannot readily accomplish without use of the software.

2. It is reasonably priced. Indeed, the worker's increased productivity far overshadowed the cost of both a microcomputer and the software. Thus, it was advantageous to businesses to provide such facilities to their workers who had need for them.

3. The time and effort needed to learn to use a spreadsheet is reasonable relative to the available time and capabilities of many businesspeople. One does not need to be a "rocket scientist" to learn to use a spreadsheet. In some sense, the compelling application embodies some of the knowledge of a field, so that the user can more rapidly gain a functional level of skill, as compared to a person who is learning how to do bookkeeping and accounting tasks by hand.

It is important to make two points here. First, compelling is in the eyes of the learner/user. Intrinsic motivation makes an application compelling.

Second, a compelling application empowers its user to do things that are not readily done without the computer system. Spreadsheet models, along with formulating and answering "what if?" questions, are very powerful aids to representing and solving business problems.

I suspect that most of us have not thought much about how the spreadsheet and other business software has changed business education. Essentially every high school in the country has replaced its typewriter labs with computer labs. Students now learn keyboarding instead of typing. They learn to represent and solve bookkeeping and accounting problems using spreadsheets and other accounting software. They learn to develop databases, and they do "electronic" filing. The more-modern business programs are now including a focus on e-commerce, preparing their students to work in this rapidly growing aspect of business.

Desktop publishing. The Macintosh computer that first became available in 1984, with its graphic user interface, was woefully underpowered. However, it had a mouse, and it came with both word processing (allowing multiple typefaces and font sizes) and graphics software. With the aid of a relatively inexpensive laser printer, the user of such a system could do professional-level desktop publishing. Take a look back at the three components I used to define a compelling application. Clearly, desktop publishing is a compelling application for many people.

Think about what this compelling application did for mechanical drawing, engineering drawing, and graphic arts curricula at the secondary school level. And, think about the spill over into journalism courses (e.g., the school newspaper and yearbook). Indeed, we are now beginning to expect that all students develop a reasonable level of knowledge and skill in the design and layout work required in desktop publishing, even in elementary school.

Two Key Questions

Now, I want you to think about two important questions.

1. What evidence do we have that business students in our secondary schools are getting a better education because of IT?

2. What are some additional examples of compelling applications that have had or have the potential to have a significant effect on our educational system?

The first question is important because it brings a new perspective to saying what constitutes an improvement in education. We no longer consider neat penmanship or speed and accuracy in doing simple arithmetic to be major goals in business education. And although being good at spelling is still useful, its importance has decreased because of spelling checkers in word processors.

Nowadays, we want graduates who can think, and who can represent and solve the types of problems that are common to the academic areas they have studied. We want them to effectively use commonly available aids to represent and solve such problems, and we want them to be good at learning new aids as they come along. We want our graduates to have good interpersonal skills so they can work effectively with their fellow employees and with customers.

Our current business education program is much changed from the past. Relative to contemporary needs, our business curriculum from 25 years ago would be classified as "terrible." More than likely, 25 years in the future, our current business education program will be considered terrible. Because IT is such a powerful aid to solving the problems and accomplishing the tasks faced by businesspeople, we are trying to hit a rapidly moving target. (I hope you are saying to yourself: "Hmm. I wonder if there are other components of our educational system that are faced with similar difficulties because IT is changing so rapidly.")

The second question is important because it gets us started thinking about other changes that have already occurred in our educational system because of compelling applications. Moreover, it gets us thinking about whether there might be many compelling applications whose widespread use could lead to significant improvements in our educational system.

In Summary

Compelling applications from business have been integrated into our educational system and have produced significant changes in this system. A person who learns to make effective use of these compelling applications is empowered. This person can solve problems and accomplish tasks that are deemed important in our society and than cannot readily be done without the use of IT.

Perhaps you are detecting a pattern? Consider the hypothesis that compelling applications from business are apt to be powerful change agents in the K-12 curriculum. Remember that the underpinnings of science are generating and testing hypotheses. You can add to your understanding of the science of teaching and learning by testing this hypothesis. Perhaps the hypothesis is not correct. Do you know some good examples of compelling applications in business that have not had an effect on K-12 education?

Now move your thinking outside the business curriculum. Spend some time thinking about the non-business courses you teach or are familiar with. From your point of view, are there compelling applications that should be an integral component of some of these courses? Please send me your ideas about other compelling applications that have, have not, or could affect K- 12 education.

First-Order and Second-Order Uses of ICT

As noted in Chapter 2 of this book, it is quite easy to develop a personally useful level of knowledge and skill in using such tools as a word processor, email, and a Web browser. For many people, these three tools are sufficient justification for owning and regularly using a computer. Taken together, they are a compelling set of tools. Other people find that computer games (perhaps played over the Internet) provide more than enough reason for owning and regularly using a computer.

Essentially all students in our formal precollege education system are learning how to use a word processor, email, Web browser, and various forms of edutainment (a word that combines educational and entertainment) or entertainment software. However, the nature and extent of this ICT use in schools just touches the surface of the current capabilities of ICT in education. The following article I wrote for *Leading and Learning with Technology* explores the idea of moving beyond such superficial uses of ICT in education.

Getting to the Second Order

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This was an invited article that appeared as part of the celebration of the start of the 30th year of publication of Learning and Leading with Technology. I founded this publication in 1974 and served as Editor-in-Chief until the end of April 2001.

I am pleased to have the opportunity to write for the first issue in Volume 30 of Learning & Leading with Technology. When I started this periodical nearly 30 years ago, I gave little thought as to what its future might be.

Like Learning & Leading with Technology, the field of Information and Communication Technology (ICT) in education has come a long way--but it has just scratched the surface of what is to come. During the past three decades, ICT has had some limited effect on curriculum content, instructional processes, assessment, and the professional lives of educators. But, for the most part our educational system has been "business as

usual," with many small (incremental) changes. In total, our educational system has not changed much during this time.

Contrast this with the ICT-based changes outside of our educational system (Christensen, 2000; Moursund, 2001). There have been substantial gains in productivity attributed to ICT. Many new companies have been created and have prospered, and many other companies have proven unable to effectively deal with ICT-related changes.

My prediction is that the next three decades will see ICT being a disruptive force in education. Large changes will occur, and many of our schools and school systems that attempt to follow the "traditional" path of the past decades will not prosper. This article looks at where ICT in education is headed and what educators can do now to help significantly improve the quality of education our students are receiving.

Incremental Change

On May 6, 1954, Roger Bannister became the first person to break the 4-minute barrier in the mile foot race. Since then, through better training, changes in the track surface, better running shoes, and so on, the world record for the mile has been broken a number of times, and it is now about 3 minutes 43 seconds. This is an excellent example of incremental change, with small changes occurring from time to time. Note that the total improvement has been less than 8%.

Now, think about two possible goals in people movement:

- The goal is to have a person run a mile as fast as possible, aided by "simple technology" such as good running shoes, a good running track, good coaching, and rigorous training.

- The goal is for an ordinary person to quickly move a distance of a mile using appropriate, safe, modern technology.

Clearly, the more sophisticated technology that is allowed in achieving the second goal has made it easy for most people to break the 4-minute mile. Indeed, the technology need not be very sophisticated. Bicyclists and motorcyclists can move faster than the fastest runners. The first locomotives powered by steam engines were not an incremental change in transportation--they were a revolutionary change that contributed to significant changes in our society.

Amplification Versus Second-Order Change

Desktop Publication Example

To a considerable extent, new inventions are first used to "amplify" (do better, faster) what we are already doing (Moursund, 1997). Thus, a word processor can be used like an electric typewriter that has a memory. Using a word processor like an electric typewriter is an amplification (i.e., first-order) use of ICT. This type of use eventually led to desktop publication, a second-order use of the technology. Desktop publishing includes:

- design for effective communication

- appropriate use of styles and templates

- appropriate use of typefaces and color

- appropriate use of graphics; and

- meeting contemporary publication standards

The word processor and desktop publishing facilitate the "revise, revise, revise" and the publishing phase of process writing. Desktop publishing was a disruptive technology, and it substantially changed the publishing industry.

Three conditions need to be satisfied to move from first-order to second-order applications of ICT:

1. appropriate hardware and software

2. a clearly recognizable benefit (i.e., intrinsic motivation) to people who potentially could make the move

3. formal and informal training and education to help interested people make the move

For desktop publishing, the appropriate hardware and software became re available with the introduction of the Macintosh computer and desktop laser printer in 1984. Many people in publishing recognized the potential and were intrinsically motivated to move to desktop publishing. Through self-instruction, learning from their peers, and workshops and longer courses, a large number of people achieved levels of expertise that met their needs.

Some people would claim that our K-12 students have also made the move, because essentially all high school graduates know how to use a word processor. However, for most of them, use of a word processor is essentially at the amplification level and is far from meeting contemporary standards for desktop publishing.

Essentially the same analysis holds for developing and publishing documents in an interactive multimedia environment, and for a number of other uses of ICT. Many students and teachers find a variety of ICT applications to be intrinsically motivating. However, relatively few K-12 students have moved significantly beyond the amplification level in their uses.

Why is this? Let's go back to the three conditions necessary to move from first-order to second-order use.

1. Appropriate hardware and software. This is available in essentially all schools. Indeed, perhaps 2/3 of students have appropriate facilities at home. Thus, this is not the reason why so few students move beyond amplification of first-order ICT applications.

2. Clearly recognizable benefits. For the most part, curriculum developers, teachers, students, and many other stakeholders do not recognize the potential benefits of moving beyond amplification. For example, I am not aware of any statewide assessment of students that tests for knowledge and skills in desktop publication, interactive multimedia publication, or full integration of ICT in math and science education. Such an assessment would need to be in a hands on mode, with the electronic copies being carefully analyzed and graded. Most K-12 students lack the maturity to recognize that something is missing in their ICT education, and they lack the knowledge of potential benefits of the second-order applications we are discussing.

3. Training and education. Of course, self-instruction opportunities for K-12 students and their teachers are widely available. But, the formal instruction they are receiving--the students while they are in K-12 schools; the teachers while they are in their teacher education programs and inservice education--is totally inadequate to the task.

ICT in Math Education Example

The same type of analysis as was used with desktop publishing is relevant to math education, but additional issues will emerge. [You can read more about ICT in math education in Moursund (2002a) listed at the end of this article.] Moreover, the approach used here can be applied to other disciplines.

Begin with a set of goals for education in the discipline being analyzed. In math education, we want students to:

1. Learn math and how to solve math problems that they encounters as they, work, study, and play in a wide variety of discipline areas.

2. Learn to pose mathematical problems and represent problem situations as mathematical problems.

3. Learn how to learn math.

Let's briefly analyze the potential for ICT to affect these goals.

1. Learn math and how to solve math problems. Perhaps the largest potential ICT effect in math education is that calculators and computers can solve a very wide range of math problems. Thus, at the current time our math education system spends the majority of its teaching efforts and time helping students learn to do procedural tasks that machines can do faster and more accurately. The analogy with the mile foot race and traveling a mile aided by technology seem particularly powerful to me. A person plus machine can out perform a person alone in a wide variety of math problem-solving tasks. For example, consider graphing of functions and data.

2. Learn to pose mathematical problems and represent problem situations as mathematical problems. This area is increasingly important as use of computational modeling steadily grows in each discipline. For example, one of the winners of the Nobel Prize in Chemistry in 1998 received the award for 15 years

of work in computational modeling in chemistry. All of the sciences (including math) now include computational modeling as one of their major components. Computational modeling in economics has long been a productive approach to problems in this field. The spreadsheet is, of course, a powerful aid to computational modeling in business and many other fields. The digitizing and manipulation of film and video are examples of using computational modeling that makes use of quite sophisticated mathematics.

3. Learn to learn math. Computer-assisted learning (CAL), intelligent computer-assisted learning (ICAL), and distance learning are all aids to learning math. Largely, CAL has been used at an amplification level in math education, as an automated flash card system with lots of bells and whistles. For the most part, distance learning is used to deliver the traditional curriculum. The Web is a global library, and learning to use the math global Library is part of learning to learn math. For the most part, students are not learning to use the math global library.

Let's return to our three-item list of what is needed to move from first order to second order, and look at it from a math education point of view.

1. Appropriate hardware and software. Math educators believe every student needs ready access to the ICT systems to be used in math education. This helps to explain the emphasis on handheld calculators. At the current time, the "ready access" requirement cannot be met by providing all students with handheld Internet-connected computers, or laptops and desktop machines. Progress in handheld computers and wireless technology is gradually eating away at this problem.

2. Clearly recognizable benefits. The use of handheld calculators on state and national assessments is now generally accepted. Many students choose to carry a calculator and/or to have one readily available at home. But, little progress has occurred to allowing students to use more sophisticated ICT on math tests--thus, there is a severe restriction to potential benefits to students.

3. Training and education. It takes very little time to learn to use a four-function calculator at an amplification level. However, ask yourself the following three questions:

   a. Do my students and I know how to make effective use of the memory (e.g., the M+) and the numerical constant features of a simple calculator?

   b. Do my students and I know how to detect and correct keying errors?

   c. Do my students and I use a simple calculator comfortably and easily in a manner that brings this computational power to all subject areas that we address?

Very few teachers answer "yes" to all of these questions. It is evident that it takes significant training and education to move beyond the amplification level in use of a simple calculator. The learning effort required for more powerful calculators and for computers is much larger.

Now, let's imagine what would constitute moving math education into broad-based second-order ICT applications. Again, I follow my list of three necessary conditions for this.

1. Appropriate hardware and software. Students need a computer system with a large display, a full-size keyboard, and good connectivity. They need a full range of software that is designed to support the learning and using of math both in a math classroom environment and in the other environments (school, home, work, play) that they encounter.

2. Clearly recognizable benefits. Students will recognize the benefits when the tool becomes an integral component of curriculum, instruction. assessment, and application in both the math classroom environment and in a wide range of environments outside of the math classroom. Students will be able to accomplish math-related tasks that they want to accomplish (intrinsic motivation) and cannot accomplish without the technology.

3. Training and education. A substantial change in math education is needed to achieve second-order effects. Although calculators have given us some hints as to what is possible, calculators are too limited to transform math education. Imagine, for example, the effects of all K-12 students having routine access to "just in time" highly interactive intelligent computer-assisted learning and distance learning that covers all topics in the K-14 math curriculum. This instruction would include built-in, routine use of the capabilities of an ICT system. It would be provided on an ICT system with a large viewing screen, good keyboard as well as voice input, and good connectivity to the Internet.

Problem Solving

Each academic discipline addresses the issues of representing and solving the problems within the discipline. In this section, I use the term problem solving to encompass a variety of tasks such as:

- posing and answering questions
- posing and solving problems
- posing and accomplishing tasks
- posing and making wise decisions
- using higher-order, critical, and wise thinking to do all of the above

Figure 3.1 illustrates six steps that might occur as one encounters and works to solve a math problem situation. The same type of diagram exists for each discipline area. At the current time, however, the point I am trying to make is perhaps best illustrated in math.
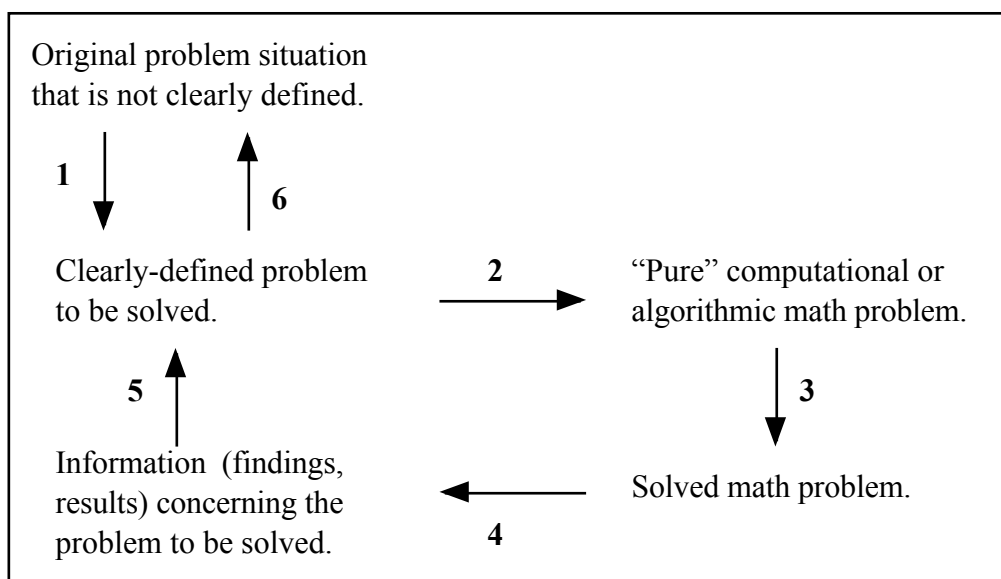
Figure 3.1. Diagram of math problem solving.

The six steps are:

1. Understand the problem situation and translate into a clearly defined problem. What is the given initial situation and what is the goal? What are the resources and rules that apply to solving the problem? (Moursund, 2002b).

2. Model the problem as a math problem. That is, translate the problem into a "pure" math problem. This is somewhat akin to what one does in translating a word problem into a set of equations to be solved.

3. Solve the pure math problem.

4. Translate the results back into a statement about the problem to be solved. This can be thought of as unmodeling, sort of the opposite of step 2.

5. Check to see if the problem has actually been solved.

6. Check to see if the original problem situation is resolved (solved). If it hasn't, reformulate the problem situation and/or problem and start over at step 1 or 2.

Estimates are that approximately 75% of K-12 math education time is spent helping students learn to do step 3 with reasonable speed and accuracy. Thus, the time spent learning the other steps is quite limited.

Step 3 is what calculators and computers do best. That is, the great majority of the K-12 math education curriculum consists in teaching students to compete with machines! This suggests that we might decrease

the time spent in teaching by-hand methods of doing step 3, and spend the time that is saved in developing greater skill in doing all of the other steps. This would represent a substantial change in math education.

Remember, the analysis in this section focused on math. However, the diagram of Figure 1 is applicable in any academic discipline. Steady progress in each discipline is increasing the number of step 3 procedures that can be carried out by an ICT system and in which ICT is a major help to a person carrying out a procedure.

Science of Teaching and Learning

There is a large and rapidly growing body of knowledge called the Science of Teaching and Learning (Bransford et al., 1999). This research and practice-based knowledge provides a foundation for substantial improvements in our educational system. The problem, however, is how to achieve widespread implementation of this research and practice-based knowledge.

One way to think about this is to consider what can be mass produced and/or mass distributed, and what cannot. For example, it is very difficult to change the educational knowledge and skills of a few million teachers. It is relatively easy to mass-produce and mass distribute four-function handheld calculators. Although the writing of a book or a piece of software is typically done by a small number of people (not mass production), a book or software itself can be mass reproduced and mass distributed.

If ICT is going to help in substantially improving education, it will be through aspects of curriculum content, instructional processes, and assessment that can be mass-produced and/or mass-reproduced, and mass-distributed. The following list provides some examples. It provides some insights into the future of education.

1. Highly interactive intelligent computer-assisted learning (HIICAL) can be mass reproduced and mass distributed. Eventually we will have HIICAL that covers the full range of curriculum that a K-12 student person might want to study. This will be a slow, gradual process. HIICAL will incorporate what is known about the science and practice of effective teaching and learning. Eventually we will have a substantial amount of HIICAL that can teach better than an average classroom teacher who is attempting to teach a whole classroom full of students. At the current time there are a modest but growing number of examples of such HIICAL. An excellent example is provided by the Fast ForWord software used to help severe speech delayed students (Fast ForWord, 2002). Some of the "Help" features being built into modern pieces of software can be categorized as HIICAL.

2. Software that can solve or help solve a specified category of problems can be mass-reproduced and mass-distributed. Examples include the spelling checker, thesaurus, and grammar checker in word-processing software; math problem-solving software such as Mathematica or Maple; and statistics and graphing software. It is disruptive to curriculum content when curriculum is changed from teaching students to do tasks by hand to teaching students to do such tasks in a computer-assisted environment. Many teachers are skilled in teaching the lower-order skills needed in problem solving and are not comfortable moving to an emphasis on higher-order skills.

3. Interactive assessment (computer-assisted testing) making possible both self-assessment and assessment at a time that is convenient to the student. Though such tests are expensive to develop, they are gradually coming into widespread use. Eventually it will be possible for students to easily assess themselves on whatever they are striving to learn. Often this is a feature of HIICAL.

4. Individualized instruction. Constructivism and individualization are highly touted in education, but are not well implemented. This is partly because an individual teacher cannot readily know in detail what each of their students knows and adjust the instruction so that it builds on the knowledge each individual student already has. At the current time, developing and implementing an individual education plan is costly relative to the current per-pupil costs of general education. An interesting aspect of ICT is that it can support a great deal of individualization in a mass-production mode.

5. All students will have routine access to the Web. Neither the teacher nor the books available in one's classroom or school library hold a candle to the size of the emerging global library available on the Web. It is somewhat disruptive to a teacher for students to find information the teacher does not already know.

Concluding Remarks

The totality of human knowledge continues to grow quite rapidly. Thus, our educational system is faced by content-related problems:

1. What should we help students store in their heads? Remember, a student can learn only a tiny (and steadily decreasing) fraction of the totality of human knowledge. Thus, our educational system needs to continually reexamine this issue.

2. What should we help students learn to do making use of aids such as ICT, books, and other mind tools? Remember, a steadily growing amount of this knowledge is stored in computers in "the ICT system can do it for you" mode (as in step 3 of Figure 1).

ICT can help students to learn more, better, and faster. Still, such improvements are incremental. They are not second-order changes. They cannot hope to begin to make a dent into the rapidly growing totality of human knowledge.

ICT can solve many of the problems and accomplish many of the tasks that students are currently learning to do by hand. Moreover, ICT can help students become substantially more productive in solving problems and accomplishing tasks. If appropriately educated, a student working with an ICT system can far out perform a student who lacks such an aid in a wide range of problem-solving tasks. Our educational system will be significantly change education in the next three decades as it incorporates the idea of educating students and ICT to work together.

For ICT-using teachers, the message is clear. Work to move yourself and your students--your curriculum, instruction and assessment--from amplification (first-order) uses of ICT to second-order uses of ICT.

Resources

Fast ForWord: http://www.scientificlearning.com/

Maple: http://www.maplesoft.com/

Mathematica: http://www.wolfram.com/products/mathematica

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Terms

Computer-Assisted Learning (CAL): Includes drill and practice, tutorials, simulations, and virtual realities designed to help students learn. CAL includes the "Help" features built into software applications and can be a component of a Web-based distance learning course.

Constructivism: The learning theory that students construct knowledge by building on their current knowledge. This theory helps make the distinction between teachers teaching and students learning, and it supports the need for individualization of instruction.

Disruptive Technology: A new technology that is disruptive to a current business or way of doing things. For example, the automobile was disruptive to the horse and buggy industry; the microcomputer and word processing software were disruptive to the typewriter industry.

Highly Interactive Intelligent Computer-Assisted Instruction (HIICAL): Begin with CAL. Design it so there is a great deal of interaction between the computer and the learner. Enhance this with artificial intelligence to improve the quality of the instruction and the interaction. The result is HIICAL. For more, see L&L 28(7).

Information and Communications Technology (ICT): ICT is an expansion on the term information technology (IT) designed to stress that communications technology such as the Internet is an important component of the field.

Intelligent Computer-Assisted Learning (ICAL): Use of artificial intelligence to improve CAL. For example, an ICAL system may contain models of the learner, the curriculum content, the teaching process, assessment, reward structures, and so on. These are combined and used in an intelligent fashion to increase the quality, quantity, and speed of student learning.

Final Remarks

Some people find one or more pieces of software to be compelling—intrinsically motivating and attention grabbing. For a child, the piece of software might be a game, an educational game (edutainment), a program for creating and/or editing graphics, or perhaps a word processor.

However, relatively few students are intrinsically motivated to learn a wide range of general-purpose computer tools. And, still fewer students are intrinsically motivated to learn to routinely use such tools at a second-order level. If you doubt this assertion, take a look at yourself and at your fellow inservice or preservice teachers. Do you see a plethora of people making routine second-order uses of a wide variety of ICT tools?

For most students, a combination of extrinsic and intrinsic motivation is needed to learn to use a wide range of general-purpose ICT tools. Our educational system has the dual challenge of helping students learn to use these tools and creating an environment in which it is to the learner's advantage to learn to routinely and effectively use these tools. That is, our schools need to create situated learning environments in which students routinely are facilitated in making second-order uses of a wide range of ICT tools. This is a responsibility of every classroom teacher.

Activities for Chapter 3

1. The **A Bit of History** section of this chapter mentioned timeshared computers. The term was not defined. Thus, you were left with the task of drawing on your own knowledge and the context provided by the paragraph in order to build an understanding of what was being discussed. You were given an opportunity to practice constructivism. Did you think about "time shares" in real estate? Did you think about how computers process credit card transactions? Did you do a Web search or look in a dictionary? Think about your constructivist activities in dealing with this term.

2. Think about your own current uses of ICT. What use do you find to be most compelling (to you), and why? How did you first get introduced to and interested in this compelling application?

3. Think about your own current uses of ICT tools. Divide them into first-order and second-order uses. Select one of your first-order uses that is somewhat intrinsically motivating (compelling) to you. What would it take for your use of this application to become second-order for you?

4. Select a grade level or subject area that you teach or are preparing to teach. For this teaching situation, select one piece of software that you feel is very important to emphasize. That is, think about a piece of software that is compelling to you and that you

would like your students to find compelling. How would you go about creating a situated learning environment that is extrinsically motivating and that would move your students to second-order use of this piece of software?

Chapter 4

Generic Computer Tools

"Computer Science is no more about computers than astronomy is about telescopes." (Edsger Dijkstra)

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

This is the first of a sequence of chapters that explore various components of the field of ICT in education.

The term "generic tool" is used in this document to represent ICT tools useful in many different disciplines and that might be taught to most or all students at the PreK-12 level. Each has been found to be compelling by a large number of people and each is commercially viable. Typical generic tools include:

- Word processor.

- Database.

- Spreadsheet.

- Graphics (both Paint and Draw).

- Graphing (of data and functions), using both computers and graphing calculators.

- Desktop publication systems.

- Desktop presentation systems.

- Multimedia and interactive non-linear hypermedia systems, including working with digital still and motion video, color, sound, and animation.

- Telecommunications and connectivity, including email, the Web, search engines, and groupware.

- Calculators (the full range, from low-end 4-function calculators to high-end calculators that can solve equations, graph functions, and may be programmable).

The International Society for Technology in Education and a number of other people and organizations have made recommendations about students learning to use generic tools. For example, the National Council of Teachers of Mathematics has supported use of calculators in the curriculum since 1980. ISTE believes that all students can and should develop a reasonable level of skill in use of almost all of the tools listed above by the end of high school. Indeed, ISTE recommends that most of the initial phases of learning to use these tools should be completed by the end of the 8th grade (ISTE NETS, n.d.).

An examination of the software for these various application areas indicates that the software is steadily improving, but is typically growing more complex. It also reveals the development of "templates" that contain substantial knowledge on appropriate use of the tool. Simple examples

are provided by templates for various types of letters to be used in correspondence, or templates for various types of slides (visuals) to be used in a presentation.

There tend to be three commonly used approaches to helping students learn generic tools. In one approach, instruction in the tool occurs in an ICT course or unit of instruction. For example, in an elementary school a "computer teacher" might present the instruction in a computer lab. A second approach is for the instruction to be presented as part of a non-ICT course or unit of study, with the instruction being presented by the regular classroom teacher. For example, students in elementary school might learn to use a 4-function calculator during their math instruction, and might learn to use the Web during a social studies unit. A third approach is to assume that students will learn from each other if/when the teacher creates an environment that supports this type of peer instruction. Each approach has advantages and disadvantages.

Keep in mind that a good teacher has good knowledge of the content to be taught as well as good knowledge of the pedagogy to be used. At all age levels, students are able to help each other learn. However, typically a student who is helping a peer or a younger student to learn lacks both the in-depth content knowledge and the pedagogy knowledge that are needed to do a good job of facilitating learning. In ICT, peer instruction is quite successful in helping students to learn some of the basic skills, such as how to put more paper into a printer, how to use a scanner, how to take pictures using a digital camera, how to move pictures from a digital camera into a computer, some of the elements of using a word processor, and so on.

At one time many elementary schools set up structures whereby students could demonstrate basic ICT knowledge and skills, and then be "certified" to instruct and/or test their peers in these areas. Many teachers found this to be a quite successful approach. It works well when the emphasis is on students learning "rote" methods of accomplishing certain tasks. It does not work well when the emphasis is on understanding, higher-order knowledge and skills, and dealing with complex problems or tasks.

An ICT teacher tends to know more than the regular classroom teacher about the generic application being taught and tends to be more skilled and experienced in teaching ICT. Since the same teacher may be teaching all students at a particular grade level, or all students in a school, this helps to ensure a common base of student knowledge about the application.

However, the instruction given by an ICT teacher in a computer lab is often not closely related to the curriculum that students are currently studying in their regular classroom. Transfer of learning to the regular classroom and the subjects being studied may be weak, or may not occur.

In addition, it often happens that the regular classroom teacher does not attend and participate in the instruction provided by the ICT teacher. Thus, the regular teacher does not know what his or her students are learning about ICT and does not gain in knowledge of how to teach this aspect of ICT.

The ISTE National Educational Technology Standards for Teachers calls for teachers to meet the 12th grade ISTE NETS for Students as well as having knowledge and skill in use of ICT in curriculum, instruction, and assessment (ISTE NETS, n.d.). Thus, a good approach to use when an ICT teacher is teaching the basic of use of generic tools (especially at the PreK-5 levels) is:

1. The ICT teacher and the regular classroom teacher work together to plan the computer lab instruction so that it incorporates activities that are relevant to the current curriculum in the regular classroom.

2. The regular classroom teacher serves as an assistant in the computer lab as his or her students receive ICT instruction on generic applications.

3. The regular classroom teacher then immediately reinforces this integration of ICT into the regular classroom curriculum by class discussions and activities. The regular classroom teacher provides the needed ICT instruction for students who may have missed the "computer lab" day and/or who need additional instruction to achieve an appropriate level of knowledge and skills.

4. The next year, the regular classroom teacher provides the ICT instruction in the computer lab, or provides the needed instruction in his or her regular classroom.

Another approach is to have the ICT teacher come to the regular classroom and work together with the regular classroom teacher to present instruction about ICT generic applications. The regular classroom teacher learns how to conduct such instruction by seeing it role-modeled, and so becomes qualified to provide the instruction his or her own.

In summary, every classroom teacher has a responsibility to learn to make effective use of the ICT tools that his or her students are learning to use. Moreover, the classroom teacher has a responsibility to be able to assist his or her students in gaining increased ICT knowledge and skills, especially in areas that relate to the curriculum the teacher is teaching. The needed teacher ICT knowledge and skills can be learned on the job by an appropriate combination of inservice education, observing and helping a computer teacher or other classroom teachers, practicing with his or her students, and self-instruction.

A preservice teacher can gain some of the needed ICT knowledge and skills through ICT coursework, ICT integrated into Methods courses, ICT integrated into practicum (field placement) and student teaching experiences, and ICT routinely integrated into the other courses taken while in a teacher education program of study.

The Challenge of Generic ICT Tools in Education

In Chapter 2 we made use of the following expertise scale for preservice and inservice teachers:
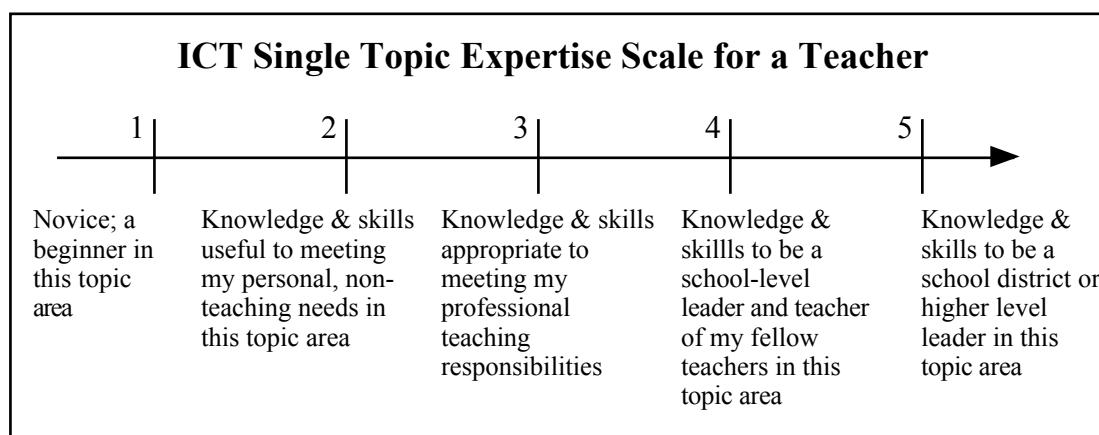
Figure 4.1. General-purpose expertise scale for a teacher.

We used this expertise scale in discussing ICT prerequisite knowledge and skills for this book in the areas of word processing & desktop publication. Through a specific focus on word

processing & desktop publication, we suggested the depth and breadth of ICT knowledge and skills needed to be a "3" on the scale in Figure 4.1

Upon initial inspection, you might well decide that becoming a "3" or higher over the full range of ICT generic tools mentioned at the beginning of this chapter is essentially an impossible task. You are aware, of course, that many students are learning to use these tools at a "2" level— a level that is useful to them. Moreover, as they gain this "2" level of knowledge and skills, they are capable of applying it to their schoolwork. The dilemma that this creates is pictured in Figure 4.2.
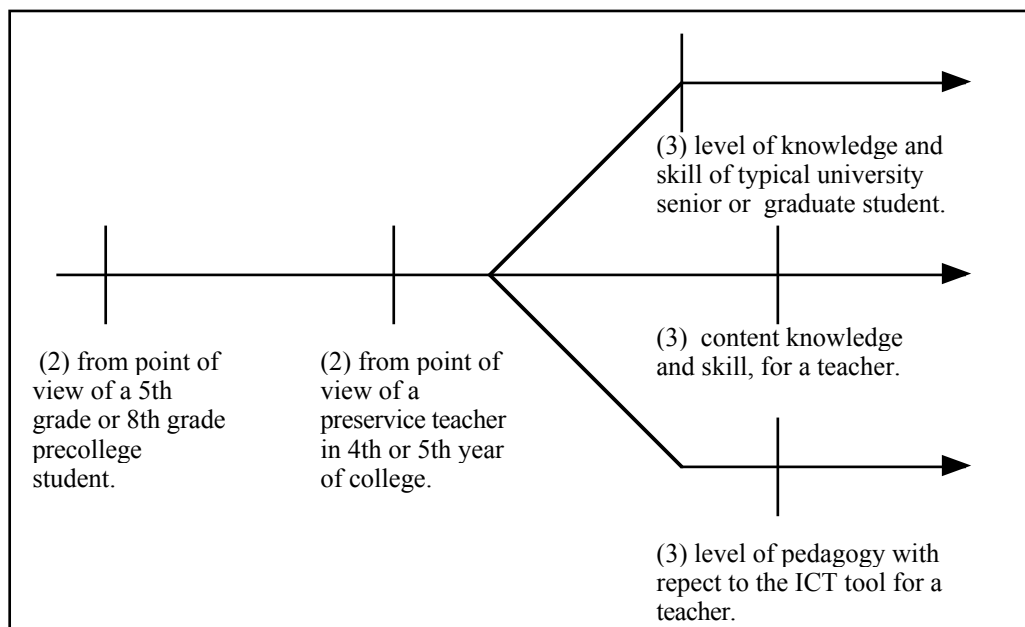
Figure 4.2. An ICT expertise "dilemma" faced by teachers.

Figure 4.2 is designed to illustrate the dual challenge that a preservice teacher faces. The first is movement up the expertise scale that is needed to maintain a useful level of knowledge and skills relative to one's overall level of education and worldly experience. The second is moving upward on three different expertise scales—one scale for ICT content knowledge and skills needed to be a student in college, the second in becoming a (3) in the content from the point of view of being a good teacher, and the third scale for ICT pedagogy both within the discipline of ICT and within the disciplines that the teacher is preparing to teach.

The three-pronged aspect of this diagram may be confusing. It is designed to suggest that a preservice teacher needs far more ICT knowledge and skills in the area of a generic computer tool than does his or her typical (non-teacher education) fellow student.

One way to think about the challenge of learning a generic application is that the typical instruction manual for such an application is several hundred pages in length. Similarly, textbooks written about a specific generic application tend to be several hundred pages in length and may be designed to serve as the text for a substantial high school or college course. This provides evidence of the complexity of a generic application.

To cite a specific example, consider Microsoft Word. I have seen estimates that the typical user of this word processor uses less than 5% of the capabilities of this generic tool. You can do

a quick check on your use of whatever word processor you typically use. Look at each item on each menu. Do you understand it fully? Then spend some time browsing the Help component of the application. What percentage of the items listed there is quite familiar to you?

Easy Entry, and Incremental Learning

This section covers a very important idea about learning ICT tools that was first mentioned in Chapter 2. Most ICT tools have the characteristic of easy entry and incremental steps toward increasing expertise. A student (you, included) can gain a useful level of knowledge and skill in using a specific ICT tool in a modest number of minutes. This allows you to begin using the tool to accomplish tasks that you deem useful to you.

As you use the tool to solve problems and accomplish tasks, you will soon run into situations that you cannot readily handle. You become stuck and you need help. People vary considerably about what they do next. Some are self reliant, going into a trial and error mode, or attempting to obtain help from an instruction manual, textbook, or the software's "help" features. Others ask for help from anybody who happens to be readily available. Still others give up.

Remember that you want your students to become independent, self-sufficient, intrinsically motivated, lifelong learners. Do you role model this set of characteristics when you encounter problems when using a piece of computer software? Suppose one of your students comes to you with a problem encountered when using a piece of software? The student is "stuck" while attempting to solve a problem or accomplish a task, and the student is somewhat or strongly motivated (perhaps an appropriate combination of intrinsic and extrinsic motivation). How do you interact with the student in a manner that will lead to the student gaining increased expertise as an independent, self-sufficient, intrinsically motivated, lifelong learner?

One of the really important aspects of students learning ICT applications while in school is that many of the basic ideas of situated learning can come into play. Being stuck when using a piece of software in school is quite a bit like being stuck when using a piece of software at home or on the job. Thus, you want to help your students become unstuck with a clear picture in mind that you want transfer of learning to occur to outside of school settings now and in the future.

A Scenario of Learning to Use a Word Processor

Consider Pat, a pre-literate child of average intelligence, perhaps three or four years old, growing up in a home where the parents have a computer and use computers on their jobs. Think about Pat's first exposure to using a word processor. Pat has learned some or all of the letters of the alphabet and perhaps the spelling of his or her name. Thus, Pat can sit at a keyboard (probably on a parent's lap), key in letters and see them appear on the display screen, and perhaps key in the letters of his or her name.

Next, think about Pat just finishing the third grade. Pat has grown up in a computer-rich home environment and attended a school that places significant emphasis on learning to make use of ICT. Pat has learned to read and is just beginning to read to learn. (This is a transition that an average child can make by the end of the third grade.) The school has emphasized rudiments of touch keyboard and developing the beginnings of automaticity in keyboarding. Thus, Pat keyboards at 10 to15 or so words per minute, which is faster than he or she can print and/or handwrite.) Pat knows how to correct keyboarding errors, do very rudimentary editing at a keyboard, and how to print out a word-processed document. Also, Pat knows how to use a portable keyboarding unit (such as an AlphaSmart®) for keyboarding text, and how to transfer this text into a laptop of desktop microcomputer.

Now, continue to follow Pat through the end of the fifth grade. Pat now keyboards at 25 words or more per minute, and is comfortable in composing at a keyboard. The increasing speed has come from use of computer-assisted learning software and self-instruction. This speed requires and achieves a level of automaticity that does not disappear if not used over a period of time, such as a summer. Twenty-five words per minute is far faster than a typical child can print or write. Pat uses a spelling checker and is adept at correcting spelling errors. Pat also makes routine use of the built-in dictionary and the grammar checker, and has learned the rudiments of desktop publishing. Pat saves documents to a server and to a portable medium, such as a removable disk, moving documents from school to home and from home to school, and is quite comfortable with using different makes and models of computers.

We continue to follow the word processing exploits of Pat through the eighth grade. Now Pat makes use of a style sheet and can create a new style sheet to fit a new writing situation. Pat makes use of bulleted and numbered lists, and tables. Pat is relatively skilled in doing layout and design of a document to be desktop published, where the document includes pictures, graphics, and multiple fonts, and may be a tri-fold brochure or a newsletter. Pat is accomplished at using email attachments to send and receive word-processed documents.

While we could continue to follow Pat's word-processing exploits through the end of high school, we can see that a pattern has emerged. Perhaps Pat continues to use computer-assisted instruction software designed to teach "fast keyboarding" in middle school or high school, and learns to keyboard at 50 words per minute. Perhaps Pat learns to make effective use of a voice input system and to make effective use of a combination of voice input and keyboarding. Word processing and desktop publishing have become routine, everyday (and, typically, many times a day) powerful tools for Pat. This set of tools facilitates Pat in doing process writing better than a child who lacks the ICT knowledge and skills. The set of tools facilitates the Pat in designing and creating desktop-published documents that communicate effectively. Finally, as the need arises, the Pat learns new features of a word processor (constructs new knowledge and skill, building on previous knowledge and skill) with little or no aid from formal instruction provided by a teacher.

Pat's scenario is designed to suggest a combination of school and home environments that fosters incrementally increasing knowledge and skills, year after year. Relatively little direct instruction is provided in school, but a facilitative and encouraging environment is provided by many teachers, year after year. Pat benefits from increasing knowledge and skills, and so intrinsic motivation helps to drive Pat's progress. However, Pat's parents and Pat's teachers all play a significant role in the overall process.

Desirable Levels of Expertise

There are a number of generic tools that have the characteristic that a student can gain a useful level of knowledge and skill in a very short period of time. Word processor, email, and Web browser tend to have this characteristic. For these and all generic applications we can think of an expertise scale such as the one shown in Figure 4.3.

Expertise Scale for a Generic ICT Tool

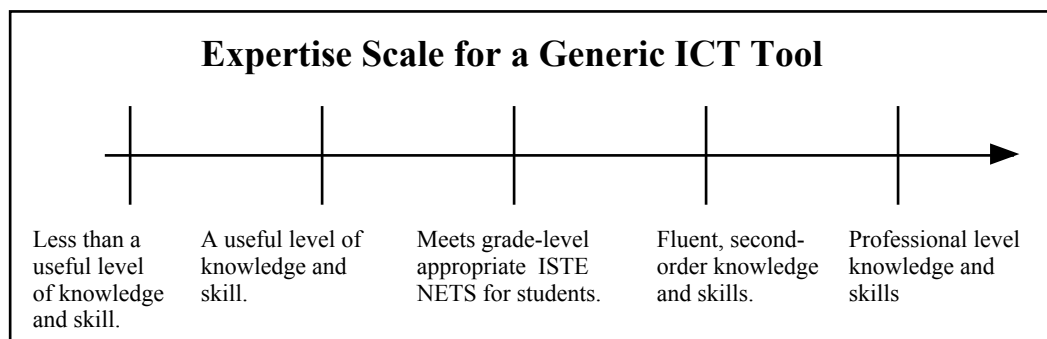| Less than a useful level of knowledge and skill. | A useful level of knowledge and skill. | Meets grade-level appropriate ISTE NETS for students. | Fluent, second-order knowledge and skills. | Professional level knowledge and skills |

Figure 4.3. Expertise scale for a learner learning a generic ICT tool.

The story of Pat given in the previous section illustrates a student achieving "fluent, second-order knowledge and skills" in use of a word processor by the end of high school. Pat may also have gained fluent, second-order knowledge and skills in use of email and the Web.

But, what about a wide range of other generic tools? A lot depends on the schools Pat attended and the teachers Pat had. Pat clearly has the potential. However, for many of the Pats in our schools, the potential is not achieved. As a preservice or inservice teacher, you should set a personal goal of helping to facilitate your students to achieve fluent, second-order knowledge and skills over a wide range of generic ICT tools.

Generic Tools and Problem Solving

The story about Pat included some emphasis on learning to use a word processor and desktop publishing to help solve the problem of effective written communication. By and large, ICT preservice and inservice education place little emphasis on problem solving, critical thinking, and other higher-order knowledge and skill. Such instruction tends to assume that the learner will transfer ICT knowledge and skills into non-ICT disciplines and will easily integrate the ICT knowledge and skills into these disciplines. Unfortunately, for most students this does not occur.

As an example, consider a student's PreK-12 education in the Social Sciences. The Web provides access to a huge amount of historical and current date and information. However, the data and information is of varying levels of correctness, has varying levels of readability, and covers a huge range of topics.

To be even more specific, consider what a student might learn about the discipline of history. What does it mean for a student to gain increasing expertise in a discipline such as history? What roles does the Web play in this?

We all know that learning history includes learning some facts (names, dates, places, etc.) However, even more important is learning to pose historical problems, develop hypotheses, find evidence and develop logical arguments to support these hypotheses, and so on. Remember, each discipline is defined by the problems it addresses, its culture and the methodologies and tools it uses, and the results it has achieved. ICT provides tools that are useful in any academic discipline of study.

Clearly the Web is now an excellent aid to finding primary resources, to exploring the collected historical knowledge that has been accumulated by the human race, to finding alternate viewpoints on historical events, and to explore causality A student can gain such knowledge and skills through appropriate instruction and thorough participation in appropriate history-oriented situated learning environments. It is easy for a student to gain a rudimentary and useful level of

knowledge and skill in using the Web. It is a significant challenge for a student to move up the "history education" expertise scale and to learn to make effective use of the Web as part of being a historian.

Activities for Chapter 4

1. Select three or more generic ICT tools that you use. For each, think about how you learned to use the tool and what recent progress you have made in moving up the expertise scale for knowledge and skill in using this tool. Compare and contrast your answers among the three or more generic tools you are exploring.

2. Here is a little material about email quoted from http://darkwing.uoregon.edu/~moursund/ICT-planning/. Analyze this information and your preparation in email from the point of view of Figure 4.2.

   Email includes sending and receiving messages (including saving and deleting messages), sending and receiving attachments, building and maintaining an address book, building and maintaining a Distribution List, participation in chat groups, making use of News Groups, and making use of instant messaging. It includes the knowledge of avoiding responding to all of the people in a Distribution List when you really only want to respond to one specific person in the list

3. Select six or more of the generic tools list given in this chapter. For each, discuss the types of problems and/or tasks that this tool was primarily designed to help solve. (Perhaps you might want to look at the history of the development of each of these tools from a causality, or "need for the tool" point of view.) Then explore the problem-solving or task-accomplishing advantages that the generic ICT tool user has when competing with a person who does not have access to ICT facilities and/or lacks knowledge and skill in using the generic tool.

4. Select a grade level or a subject area that you teach or are preparing to teach. Suppose that the average student entering your class is somewhat below grade level) in terms of ISTE NETS for Students) in use of one specific ICT generic tool. Describe what you can do to create a situated learning environment that provides extrinsic motivation, encourages intrinsic motivation, is constructivist, and moves your average student to routine second-order and grade level appropriate use of this generic tool.

5. Select a grade level or a subject area that you teach or are preparing to teach, and select a generic tool that you feel is appropriate to this grade level or course. Discuss the higher-order problem solving and critical thinking aspects of this generic tool with respect to students you will be teaching.

Chapter 5

ICT as Curriculum Content

"... pedagogy is what our species does best. We are teachers, and we want to teach while sitting around the campfire rather than being continually present during our offspring's trial-and-error experiences." (Michael S. Gazzaniga, 1998)

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

This chapter explores the idea of ICT as curriculum content in precollege education. The focus is on:

- ICT as a discipline in its own right. This discipline is often called Computer and Information Science.

- ICT as a discipline-specific component of non-ICT disciplines. For example, one of the winners of the 1998 Nobel Prize in Chemistry was awarded this prize for his previous 15 years of work in Computational Chemistry. By the early 1980s "Computational" had begun to be an important part of the content area in many different disciplines, including all of the core curriculum area: language arts, math, science, and social science.

Characteristics of a Discipline

The content of our PreK-12 curriculum is divided up into a number of large chunks that come from a variety of disciplines. Many people consider the most important "core" disciplines to be language arts, math, science, and social science. However, there are other potential candidates for "core" curriculum, including art and music.

The various core disciplines are quite different, but they share much in common. For each discipline, we can think of a learner beginning as a novice and then moving up an expertise scale. It can take years of education, training, and experience to achieve a reasonably high level of expertise. For example, reading and writing are components of language arts that are stressed year after year in the education of precollege students. Even then, many people feel that the reading and writing skills of a typical high school graduate are not "what they should be." Similar assertions are often made for the math, science, and social science knowledge and skills of high school graduates.

Another characteristic that the core disciplines share is a learning theory that includes constructivism, situated learning, transfer of learning, lower-order knowledge and skills, and higher-order knowledge and skills. The is a steadily growing Craft and Science of Teaching and Learning that is applicable to the teaching and learning of all of the core curriculum disciplines.

Finally, as we have said several times earlier in this book, each discipline can be characterized by the types of problems and tasks it addresses, its culture, including the tools and methodologies that it uses, and the results that it has achieved. That is, solving problems and accomplishing tasks are a characteristic of all core curriculum disciplines.

Communication is another aspect of all core curriculum disciplines. Communication in all core curriculum disciplines is heavily dependent on the reading, writing, speaking, and listening

components of the language arts. However, each discipline tends to develop special vocabulary for representing and communicating about the types of problems that it addresses. Thus, an important aspect of learning a discipline is learning to understand and communicate using its special vocabulary. Moreover, the discipline of ICT has developed a variety of aids to communication. Thus, each of the core curriculum disciplines is now making use of communication tools that come from ICT.

The Language of Mathematics

Mathematics is a discipline that can trace its history back 5,000 years and more. It is a discipline whose results or collected knowledge cut across all disciplines and is important in our everyday lives.

Mathematics provides a good example of a discipline that has developed special vocabulary and notation for representing and solving the types of problems that it addresses. You are undoubtedly familiar with some of the symbols used in mathematics, such as:

- the digits 0, 1, 2, … , 9

- symbols for the four basic arithmetic operations +, −, x, ÷

- a large number of other symbols such as =, ≠, <, >, ±, (,), and $\sum$.

One way to think about mathematics is that it is a language. This language includes a large number of natural language words that have been given very precise definitions for use in math, and rules for combining the words and symbols for communication about mathematical ideas. For example, the concept of "proof" in mathematics is somewhat different than the concept of proof in the social sciences, sciences, and in law.

As a discipline grows, it often is divided into sub disciplines. You are undoubtedly familiar with some of the subdivisions of mathematics, such as arithmetic, algebra, geometry, probability, and statistics. You may have studied some calculus and other sub disciplines of mathematics that are found in a typical undergraduate college degree program for math majors.

You know that math is a broad, deep, complex, and ever growing discipline. Since you know something about calculators and computers, you know that some parts of ICT are parts of the content of mathematics. We will say more about this later in this chapter.

But first, let's look at the discipline that underlies ICT.

Computer and Information Science

The discipline of computer and information science began to develop long before the first computers were built. For example, the 1890 U.S. census data was processed by putting the data onto punch cards and using automated sorting and counting machines. The history of mechanical calculators goes back well over 300 years, and the history of the abacus goes back at least 2,500 years (Redin, n.d.).

The first computer science departments (they are now often called Computer and Information Science Departments, or CIS departments) in higher education were established during the later 1950s and early 1960s. Typically this occurred in one of three ways:

- As a split off from a mathematics department, forming a department with an orientation toward math and the other areas of liberal arts.

- As a split off from one or more departments in an Engineering School, forming a department with an electrical engineering orientation.

- As a split off from one or more departments in a Business School, forming a department with a business orientation.

These early CIS departments offered programs of study that included a major focus on computer programming and solving the types of problems that occur in some specific disciplinary areas. Thus, a business-oriented computer science department might offer a variety of courses in COBOL programming, with the focus being on learning to develop computer systems to solve business problems. An early engineering oriented computer science department might offer courses in FORTRAN programming and courses about computer circuitry.

> Note: There are millions of Websites that address the history of computer programming languages. More than 2,500 different languages have been developed. Some have been designed to be quite specific to the types of problems from a narrow discipline or sub discipline, while others have been developed to be quite general purpose and useful over a wide range of disciplines.

Current CIS Departments

While the early liberal arts-oriented CIS departments included an emphasis on computer programming, they also placed considerable emphasis on developing the "science" of CIS. Thus, students in these departments studied such topics as information storage and retrieval, analysis of algorithms, and software engineering. Relatively early on, artificial intelligence became an important sub discipline in CIS (Moursund, 2004b). A few other important sub disciplines in CIS include computer networking, modeling and simulation, and human-machine interface.

One of the unifying ideas in CIS is that of **procedures and procedural thinking**. In CIS, a procedure is a step-by-step set of instructions that can be interpreted and carried out by a specified agent such as a computer or an automated machine. CIS has a strong emphasis on developing procedures that are designed to solve certain types of problems, and on thinking about the capabilities and limitations of computer procedures.

Thus, CIS brings two major things to each non-CIS discipline:

1. Procedures and procedural thinking. What aspects of representing and solving the problems in a discipline can be automated or partially automated by use of computers and other ICT? How does such automation or partial automation affect what should be taught, how it should be taught, and how it should be assessed in each of the current core curriculum areas and the other disciplines taught in our schools?

2. Various sub disciplines that are developing interdisciplinary tools. Computer networking has led to the development of the Internet and the Web. Artificial Intelligence has led to the development of voice input to computers, effective spelling and grammar checkers, significant progress in the automatic translation of languages, and a variety of other tools that are now in common use throughout business and industry. Human-machine interface has helped in the development of a number of different "assistive technology" aids for people with various types of handicapping conditions.

Historical Impact of CIS on Precollege Education

The early history of ICT in precollege education was strongly influenced by Computer and Information Science Departments and people who had a CIS orientation. As an example, computer programming was a typical component of early computer in education courses for

preservice and inservice teachers. Two programming languages received a lot of attention. BASIC is a language that was developed at Dartmouth University during the 1960s. Its use eventually became thoroughly integrated into the undergraduate college curriculum and eventually spread to precollege education. The original versions of BASIC shared much in common with the FORTRAN programming language whose original targeted language was scientists, engineers, and applied mathematicians.

The Logo programming language was developed soon after BASIC. It was based on a programming language that was developed for use by researchers and practitioners in Artificial Intelligence. Logo was specifically designed for use by grade school students, but it has the characteristic of meeting needs at all grade levels, including college and graduate school.

With the advent of microcomputers came the idea of providing generic tools (as distinguished from programming languages) that could be used by people who had not taken coursework of the sort offered by a CIS department. Very young students could learn to make effective use of a word processor. Apple's introduction of the Macintosh computer in 1984 opened the field of applied computer graphics to students of all ages. Gradually the emphasis on teaching computer programming to preservice and inservice teachers (and, to their students) faded away. Now, most preservice and inservice teachers receive very little or no instruction in computer programming. Most preservice and inservice teachers do not receive explicit instruction in procedures and procedural thinking from a CIS point of view.

However, CIS is still alive and well in a number of high schools. Many high schools offer an Advanced Placement course in Computer and Information Science. It corresponds roughly to the first year of college CIS course for potential CIS majors. It contains a strong emphasis on computer programming and problem solving.

ICT as Content in Four Core Non-ICT Disciplines

This section contains a brief exploration of how ICT is affecting the content of four core disciplines or fields of study: language arts, mathematics, science, and social science. Let's begin with a summary of what we **do not** focus on in this section.

- **Generic Tools.** Generic ICT tools tend to cut across all or most disciplines. Essentially all of the generic tools discussed in the previous chapter have become commonly used tools in language arts, math, science, and social science. For the most part, we will not provide more detail here in this section.

- **Computer-Assisted Learning.** In Chapter 7 we will discuss Computer-Assisted Learning. As you already know, ICT is now widely used as an aid to student learning in all of the core fields of study and in most other disciplines. For the most part, we will not provide more detail here in this section.

We close this section with a brief discussion about a component of ICT that is both generic and that is specific to the content of each individual discipline. Networks (including the Internet, email, and the Web) are a component of ICT that cuts across all disciplines but that is also quite specific to each discipline. Each discipline has its own ways of representing the types of problems that it addresses and the results that it has achieved. The collected knowledge from a discipline can be organized in a manner that facilitates storage and retrieval, and then placed in a "traditional" physical library, or in an electronic library such as the Web.

One aspect of learning a discipline is to learn about the storage and retrieval of information within that discipline. Thus, as a student studies science, he or she should be learning about the

sub disciplines of science and how the accumulated knowledge of science is stored and retrieved. It is not sufficient to say that a student has learned to use a browser a search engine as generic tools for searching the Web. The overall field of information storage and retrieval (including the discipline of librarianship) is much more than this. It takes considerable understanding of a discipline and information retrieval within the discipline to locate information that may be relevant to a particular problem or task, judge the quality of the information, understand the information, and make use of the information.

Language Arts

The language arts include a number of sub disciplines such as speaking, listening, reading, writing, and literature. Here are a few examples of ICT as content in the language arts:

- Before the development of the word processor, writing tended to be a linear process. A word processor facilitates skipping forward and backward, inserting, deleting, and moving major sections of text, and carrying out other non-linear writing activities. While writing in a linear paper and pencil environment and writing using a word processor are closely related activities, they differ quite a bit. The word processor, electronic outliner, spelling checker, grammar checker, built-in dictionary, and so on all play significant roles in the writing process. Thus, students can benefit by instruction on how to make effective use of a word processor when writing.

- Process writing has long been considered an appropriate model of how to teach and do writing. The final step in process writing is the "publication" phase. Desktop publication has substantially changed this phase. Desktop publication includes giving careful thought to designing a document for effective communication. Desktop publication is now a significant sub discipline in written communication.

- Interactive multimedia (such as a typical Website) is now a common environment for communication. Such multimedia often includes text, pictures, graphics, video, sound, and color. Students benefit by instruction on how to effectively read (view, use, learn from) an interactive multimedia environment. As with the reading and writing of text, the writing (creation) of multimedia documents can be considered as part of the language arts.

- Language arts includes students gaining skill in doing oral presentations. Nowadays, presentation media are commonly used in oral presentations. Developing and making effective use of presentation media is an important component of the language arts.

Mathematics

- Changes in curriculum due to changes in tools or the introduction of new tools can be subtle. For example, it used to be that students in first and second year high school algebra courses learned how to calculate square roots using pencil and paper, how to make use of math tables, and how to interpolate in math tables. Quite a bit of this content has disappeared from the curriculum; calculators have replaced it.

- Calculators can be a replacement for a substantial amount of time that is currently spent learning and using paper and pencil computational skills. Graphing and equation-solving calculators have facilitated significant changes in the content of a number of high school math courses.

- Software packages such as Maple and Mathematica can solve a wide range of the types of problems students study in arithmetic, algebra, geometry, probability, statistics, and calculus. This has led to significant changes in the content of some calculus courses at the high school and college level.

- Computer modeling and simulation are now one of the major sub disciplines of mathematics. Such computational modeling and simulation is now a common tool in engineering, architecture, all of the sciences, and a number of other areas.

- Numerical analysis is an important component of mathematics. (I did my Ph.D. research in numerical analysis). Computers are now an important component of that component of mathematics.

Science

Up until about 25 years ago, the various science disciplines tended to be classified as pure and applied—often called theoretical and experimental. ICT has brought a new category—computational modeling and simulation. By the early 1980s, some science researchers were doing their work by drawing upon the ideas from the theoretical and experimental approaches, but carrying out their work computationally. Their theoretical models were represented as computational models, and their experiments were carried out on computers. In 1998, one of the winners of the Nobel Prize for Chemistry was a computational chemist. The prize was awarded for work that he had begun more than 15 years earlier. Here are a few examples of ICT as content in the sciences:

- Microcomputer-Based Laboratory (MBL) represents a significant change in the content of various science courses due to the capabilities of laboratory instruments with built-in ICT capabilities.

- Global Positioning Systems (GPS) have replaced or supplemented a wide range of surveying and navigational non-ICT methodologies and tools.

- A variety of telescopes and microscopes now include powerful built-in computers and cannot function without the capabilities of such computers. The same holds true for much of the other instrumentation now used in the sciences.

Social Science

ICT has substantially changed our society and other societies of the world. Over the past 11,000 years, large parts of the world have moved from being hunter-gatherer societies to being agrarian societies to being industrial age societies to being information age societies. ICT is a very powerful change agent and now has a history that can be traced back well over 100 years. Thus, it is an appropriate content area for both history and current events. Here are some other examples of ICT as content in social science courses:

- The Web is now a global library that contains a large number of primary source documents. Thus, students can now obtain information from primary sources rather than just information filtered through the minds of their textbook authors.

- ICT makes it much easier to publish information and to keep published information up to date. The teaching and learning of various social studies disciplines are significantly changed by having current, up to date information readily available.

- Students can readily communicate with students throughout the country and in other countries. This change in communication capabilities is somewhat akin to providing students access to primary resources.

- Geographic Information Systems (GIS) provide a set of tools that are now routinely used in geography, environmental studies, city planning, and many other components of the social sciences. Roughly speaking, a GIS can be thought of as a spreadsheet-like piece of software designed to store and process maps and detailed data that accompanies maps.

- Economic modeling and forecasting (using computers) is now a routine component of the disciplines of economics and business.

Final Remarks

ICT now has the potential to be a significant content component of each of the core discipline areas language arts, mathematics, science, and social science, as well as other disciplines taught at the precollege and college levels. This fact creates a major challenge for our preservice and inservice teacher education programs and our methods of developing precollege curriculum standards.

Some progress is occurring in integrating ICT tools as routine aids to representing and solving problems in various components of the precollege curriculum. However, the rate of progress is slow relative to the rate of development of new ICT-based tools. Thus, there is a growing gap between the potential and the actual student learning of such tools as an aid to representing and solving the problems that help to define the various disciplines in our school curriculum.

Our educational system was not designed to cope with a rapid pace of change in curriculum content. Our society has witnessed and is witnessing the economic and social disruptions that are occurring as business and industry attempt to cope with the rapid pace of change in ICT. Some people suggest that somewhat similar disruptive events should be occurring in education. Others hold firm to the idea that education is and should be a stabilizing component of our society and social systems, and that it is desirable that this system not have a rapid pace of change.

This leaves many preservice and inservice teachers caught between a rock and a hard place!

Activities for Chapter 5

1. Each academic discipline can be defined by the problems it addresses, its culture, including the tools and methodologies that it uses, and the results that it has achieved. Pick one of the content area disciplines that you know best. Off the top of your head, define the discipline in terms of the problems it addresses, its culture, tools and methodologies, and the results that it has achieved. Then carefully examine the ICT parts of your answer. Think about how to help students gain ICT knowledge and skill within the disciplines that you know best.

2. I am particularly interested in the roles of ICT and Brain Science in math education. I have built a Website on this specific combination of topics. See http://darkwing.uoregon.edu/~moursund/Math/. No matter what area you teach in or are preparing to teach, your formal education has included a lot of instruction in math. Explore the Website deeply enough to increase your knowledge of ICT in math and math education. You might, for example, want top browse my short book for elementary teachers available at http://darkwing.uoregon.edu/~moursund/Math/El Math Book.pdf.

3. Select some discipline that you teach or are preparing to teach. To be a good teacher of XYZ (the discipline you have selected) you need to understand both the discipline and how to teach it. Specifically, you need to be able to answer the question "What is XYZ?" from the four points of view listed below. Reflect on and explain what the discipline XYZ is:

   A. In a manner that is appropriate to the XYZ maturity and current understanding of your students, and that helps contribute to their gaining an increased understanding of the XYZ discipline.

   B. In a manner that is foundational to your work as a teacher of XYZ. Your decisions about the XYZ content, instructional processes, and assessment used with your students should be rooted in your adult level, professional teacher level, of understanding.

   C. In a manner that is appropriate for explaining your roles as a teacher and what you teach to a wide range of people such as parents, your friends and acquaintances, and other people who have widely varying backgrounds in XYZ.

   D. In a manner that provides helps you as you strive to be a better teacher of XYZ. Keep in mind that XYZ is a steadily growing and changing field. Thus, for example, you might want an answer that helps you meet the challenge of Information and Communication Technology in XYZ curriculum content, instruction, and assessment.

Chapter 6

ICT as an Aid to Teaching and Learning

"Simple things should be simple. Complex things should be possible." (Alan Kay)

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

A simple-minded description of a school is that it is a place where "teachers teach and students learn." Historically, it is easy to understand why schools became places where people came together to learn and that human teachers facilitated the learning. Books were expensive and not readily available. There were relatively few well-educated scholars and teachers. Thus, people wanting to learn tended to come to places where there were books and scholars.

Gutenberg's mid 15th century development of a printing press that used movable type was a major contribution to education (Gutenberg Bible). As books became relatively inexpensive and more available, a learner could take more responsibility of his or her learning and could carry out this learning at a time and place to fit his or her convenience. ICT has added significantly to this trend.

As noted in earlier chapters, there is a steadily growing collection of practitioner and researcher knowledge called the Craft and Science of Teaching and Learning. Educators often talk about translating theory into practice. The "theory" they are talking about is our collected knowledge of the Craft and Science of Teaching and Learning. The challenge is to translate this theory into practices that improve the quality of education being received by students.

There are lots of ways to translate this collected knowledge into practice. For example, curriculum content, aids to instruction, and assessment instruments can be developed that reflect this knowledge. These materials can be widely distributed.

Another common approach is through preservice and inservice education of teachers. Continuing staff development is continued to be a crucial component of our overall educational system.

ICT brings us some very powerful new aids to translating theory into practice. This chapter addresses two of these aids, computer-assisted learning and distance education.

ICT Availability

We are used to the idea that books, telephones, and TV are readily available in most households. We are less used to the idea that computers with Internet connectivity have become a common household item. Here is some data quoted from a newspaper article (Mercury News, 2003).

In 2002, 83 percent of American family households (with at least one child aged 2–17) owned a computer, and 78 percent of children lived in a home in which either they or a parent used the Internet from home (Connected to the Future).

…

About 90 percent of people ages 5 to 17 use computers and 59 percent of them use the Internet -- rates that are, in both cases, higher than those of adults.

Even kindergartners are becoming more plugged in: One out of four 5-year-olds uses the Internet.

The figures come from a new Education Department analysis of computer and Internet use by children and adolescents in 2001. A second report from the agency, based on 2002 data, shows 99 percent of public schools have Internet access, up from 35 percent eight years ago.

These figures from 2002 are, of course, becoming increasingly out of date. As computer access continues to grow and as the nature of connectivity continues to change, we gradually take it for granted that a student has such facilities at home. We now tend to assume that every household has a telephone (hard wired or cellular), color television, and other "modern" technology. Of course, this is not a correct assumption.

Children with computers at home often have access to three or more of the following general categories of software:

- Pure entertainment (games that are not designed to be educational). Some of these games are now played online (on the Internet) with many thousands of people simultaneously playing the same game, and with teams of players often working together toward some common goals.

- Pure educational, designed specifically to provide instruction to help the user learn.

- Edutainment (lying some place on the line between pure entertainment and pure educational).

- Communication tools and reference materials, including email, Web, and laser disc encyclopedias, books, and other reference materials.

- Tools such as a word processor, graphic software (for example, software for editing photos), and other generic tools.

There are other aspects of ICT intensive home environments. Cellular telephones, handheld computer games and toys, TV, PDAs, DVD players, CD players and recorders, and video tape players and recorders are now commonplace. When children grow up in an ICT intensive home environment, they may gain many thousands of hours of experience using ICT facilities. For the elementary school age group, use of the computer and electronic games has overtaken use of TV. This (situated learning) home environment can be compared and contrasted with school environments where many students only get to use computers an hour or so a week in a computer lab.

The educational systems in the United States have made a determined effort to provide computers and connectivity in all schools. Nowadays, it is unusual to find a school that does not have computers and Internet connectivity. On average, our schools have approximately one microcomputer per five students. Roughly speaking, however, this means that students have about three times as much ICT at home as they have at school.

There is a steady upward trend in the amount of compute power and connectivity power (bandwidth) being made available to students at school, at home, and in other places such as public libraries. Moreover, wireless connectivity is gradually becoming available in large regions, such as whole cities. Futurists can "see" a time when availability and use of such mobile ICT will be routine for the great majority of people in the US and many other countries.

This trend toward ubiquitous ICT is changing our society and is slowly beginning to make a significant contribution to translating educational theory into practice. The word "slowly" is worth repeating. Our schools are struggling to meet the challenge of continued rapid change in ICT.

Computer-Assisted Learning

Over the past 50 years, many different terms have been used to describe teaching being done by a computer system. For example, computer-based instruction and computer-assisted instruction used to be common terms. There has been a gradual shift from these terms to the term computer-assisted learning. Among other things, this reflects the goal of helping students learn. Computer-assisted learning (CAL) places the emphasis on student learning rather than on teaching being done by a computer.

As with any important emerging area of the Craft and Science of Teaching and Learning, there have been a large number of CAL research studies, and the literature contains many thousands of "testimonials" (articles that are not research studies) touting the merits of CAL. A Google search of computer-assisted learning currently produces nearly a million hits.

Over the years, the research literature on CAL grew to a level that it could support metastudies. A metastudy is a careful analysis of a group of related studies (Boston, 2002). By 1994, there were enough metastudies of CAL so that James Kulik was able to conduct a meta-metastudy of CAL (Kulik, 1994). His conclusion is that, on average over a wide range of subject matter areas and a wide range of students, CAL works. Students learn significantly faster and better. Kulik reported an average effect size of about .35 (a 50th percentile student becoming a 64th percentile student) and timesaving of about 20%. That is, by 10 years ago we knew that CAL helps students learn significantly faster and better.

There have been a number of more recent metastudies on CAL. Table 6.1 summarizes some of these (NCREL).

Summary of Recent Meta-Analyses in Educational Technology			
Author(s) and Date	**Focus**	**N of Studies**	**Effect Size**
Bayraktar (2001-2002)	CAI in secondary and college science	42	.273
Blok, Oostdam, Otter, and Overmaat (2002)	Computer-based instructional simulations	42	.190
Cavanaugh (2001)	Interactive distance education technologies	19	.147
Christmann and Badgett (1999)	CAI in science	11	.266
Christmann, Badgett, and Lucking (1997)	CAI in differing subject areas	27	.209
Christmann, Lucking, and Badgett (1997)	CAI in secondary schools	28	.172
Lee (1999)	Computer-based instructional simulation	19	.410
Lou, Abrami, and d'Apollonia (2001)	Small group versus individualized learning with technology	122	.150
Whitley (1997)	Gender differences in computer-related attitudes and behavior	82	.209
	Median =	**28**	**.209**

Table 6.1. Summary of some CAL metastudies.

Notice that the fourth column of Table 6.1 gives the effect size. In metastudies, this term is the difference between the means of treated and control subjects divided by the pooled standard deviation of the two groups. The effect size can also be stated as a percentile standing, as shown in Table 6.2 (Effect Size, n.d.).

Effect Size	Percentile Standing
2.0	97.7
1.9	97.1
1.8	96.4
1.7	95.5
1.6	94.5
1.5	93.3
1.4	91.9
1.3	90
1.2	88
1.1	86
1.0	84
0.9	82
0.8	79
0.7	76
0.6	73
0.5	69
0.4	66
0.3	62
0.2	58
0.1	54
0.0	50

Table 6.2. Effect size and percentile standing.

An effect size of .20 is considered to be small, while an effect size of .50 is considered to be medium, and an effect size of 1.0 is considered to be large. Results are often also reported in terms of percentiles. Referring back to Table 6.1 and 6.2, the effect size of .209 represents a small positive effect, with the experimental group scoring at the 58th percentile of the control group distribution. The effect size of .410 corresponds to the positive effect of the experimental group scoring at the 66th percentile of the control group distribution.

Over the years, there has been a trend toward CAL becoming both more "intelligent" and more interactive. The "intelligence" in this type of CAL refers to the use of Artificial Intelligence, an important component of the field of Computer and Information Science. Thus, people now talk about Highly Interactive Intelligent Computer-Assisted Learning (HIICAL). Here is a short article I wrote on this topic a few years ago.

Highly Interactive Computing in Teaching and Learning

This article is about roles of teachers, learners, and computers in highly interactive teaching and learning. When most educators think about highly interactive computing, their first thought is about computer-assisted instruction. But, there are many other situations in which one uses a computer in a highly interactive manner. The development of a spreadsheet model, and the use of it in asking and answering "What if?" questions, provides a good example. The interaction one does in editing a photograph provides another example. This article explores various aspects of highly interactive computing and makes some suggestions about how to improve our educational system.

Computer-Assisted Instruction

We all know that a computer can be a powerful aid to learning. We know about "drill and practice" and tutorial computer-assisted instruction (CAI), and we know about simulations used to train airplane and spaceship pilots. In all of these teaching/learning situations, there is interactivity between the computer system and the learner.

In the pilot training simulations, the learner is involved in a highly interactive simulation of a real world environment. The simulation is attention-grabbing and realistic, and usually there is a high intrinsic motivation to learn. These characteristics contribute significantly to the learning process.

Drill and practice or tutorial CAI tends to lack the real world flavor of pilot-training simulations. A standard attempt to overcome this difficulty is to embed the CAI in a game-like, entertainment environment. The game-like environment may prove both attention-grabbing and intrinsically motivating. On the other hand, it is possible that it contributes little to the desired learning outcomes. This is because there may be little transfer from the learn environment to situations in which the learning is to be applied.

Transfer of Learning

Transfer of learning is closely related to the CAI ideas given above. The computer simulations used in pilot training are so realistic that there is a high level of transfer of learning to real world piloting situations. Flying the training simulator is less expensive and less dangerous than flying a real airplane or spaceship. Moreover, the computer simulation also allows the pilot to gain experience in dealing with dangerous emergency situations that are not apt to occur very frequently in the real world. All things considered, such CAI simulations have many advantages over emerging a trainee in a real world training environment.

On the other hand, the learning that occurs in more traditional CAI environments faces two transfer of learning difficulties. First, there is the transfer from the computer environment to the non-computer environment. Second, there is the transfer from the non-computer environment to the real world. To illustrate, a child may become adept at quickly doing certain mental arithmetic feats in a highly interactive and entertaining game environment. Will the child be able to display the same level of skill in the non-game environment of a traditional classroom or on a traditional pencil and paper test? And, will such traditional classroom knowledge and skill transfer to recognizing and solving somewhat similar problems that the student encounters outside the classroom?

We know how to use computers to make highly interactive simulations that are so real world-like so that there is a high level of transfer of this learning to the real world. This provides us with a target to aim at as we develop other types of CAI for use in our schools. We have not come very far in this endeavor.

Learning and "Attention" in the Human Mind

The body/brain receives input from the five senses: aural, taste, touch, visual, and smell. (For simplicity, in the remainder of this article I will use the term mind in place of the term brain/body.) Learning takes place inside the mind. This learning is influenced by what the mind consciously does to promote learning, as well as what it unconsciously does. Thus, we can think about improving learning by improving the external stimulus (what is provided from outside the mind) and by training the mind to learn better from the stimuli that it receives and from what it has stored in the past.

The mind's various input systems are easily overwhelmed by the amount of input that is or can be available. Thus, the mind is designed to not pay attention to most of the input. That is, there is a continual filtering mechanism being applied. The mind only pays attention to a very small part of the input. It pays special attention to life threatening and other dangerous situations.

The mind can consciously decide to focus its attention on certain internal and external components of its environment. That is, the conscious mind can focus its attention on stored data, information, knowledge, and wisdom, and it can also decide to pay attention to external stimuli.

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This selective attention mechanism presents a major challenge to teachers. As a teacher, you want students to pay attention to what is going on in the classroom. But, you are competing against built-in mechanisms that are designed to have the mind only pay attention to really important things. Many students automatically filter out (that is, do not pay attention to) what is going on in the classroom. After all, classrooms are designed to be safe places, so there is little chance of life-threatening events occurring, such as an attack from a tiger or a poisonous snake. In a classroom, a student's mind can safely consider events of past days or possible events in the future. These events may be far more attention grabbing than the current events within the classroom. The student pays attention to and learns about these past and possible future events, rather than what the teacher would like the student to be learning.

From a teacher point of view, there is a competition going on for the attention of a student's mind. The good teacher is able to create an interactive learning environment that helps to focus student attention on important curriculum topics. A good teacher and a good educational environment can grab the attention of the students in a class. Highly interactive computer environments can add significantly to such a learning environment.

Interactivity in Tutorial Settings

The mind is designed to be able to learn. Consider a situation faced by a very young baby. The baby's mind recognizes some form of discomfort (a belly ache, too cold) and produces the action of crying. The crying is heard by a parent. The parent makes a guess as to the source of the discomfort and takes an action to remedy the situation. This baby-parent interaction leads to learning on the part of both the baby and the parent.

A similar description fits well with a child learning other non-verbal and verbal language. This is a good example of highly interactive one-on-one "tutoring," with both the child and the adult learning from the interaction. There is a very important point to be made here. The nature, extent, and timing of the feedback provided by the tutor (the adult) is determined by the best judgment of the tutor. It is individualized and highly personalized based upon past interaction with the child.

From the type of analysis given in this section, we can identify some of the characteristics of a good tutor. It needs to:

1. Have a good "understanding" of what is to be learned and how humans learn it.

2. Have a good understanding of what the learner already knows and learning characteristics of the learner.

3. Provide feedback and interactivity that is appropriate in nature, extent, and timing.

Over the years, some progress has been made in the development of drill and practice and tutorial CAI that has these features. There has been encouraging progress in the development of Intelligent CAI systems that make use of progress that has been occurring in the field of artificial intelligence. However, we have a long way to go. Much of the interaction needed to make current CAI into a rich learning environment must come from and through the learner. This means that students need to learn to make effective use of the types of CAI that we are currently able to produce.

This is not a whole lot different than a student learning to learn from books. The CAI can be thought of as an interactive type of book. Little learning occurs in drill and practice or tutorial CAI unless the student is consciously and actively engaged, and has learned to make effective use of the medium.

Non-CAI Interactivity

I spend a significant fraction of my work time seated at a computer. I mainly use general-purpose computer tools such as word processor, spreadsheet, paint and draw graphics, E-mail, Web browser, and Web authoring software.

Typically, my goal is to solve a problem or accomplish a task. I use all of my computer tools in a highly interactive manner. This type of interaction is much different than one finds in a CAI drill and practice or tutorial environment. Sometimes I do most of the work in the interactions, such as when I am authoring using a word processor or a Web authoring system. Other times the software carries much of the burden, such as when my word processor is checking my spelling and grammar. Sometimes there is a nice balance, as my Web browser and I work together to solve an information retrieval problem.

As I work to solve problems and accomplish tasks, I learn a great deal. The combination of my mind and the computer system provides me with information to be learned and feedback during the learning process. This is consistent with *situated learning*, a learning theory that supports putting the learner into rich, real world problem-solving environments (Moursund; Roschelle). Situated Learning theory helps to explain the success of problem-based learning and project-based learning. Computers can be a valuable component of a situated learning environment.

At one time in my life, I spent a lot of time doing and teaching computer programming. In the early years, the nature of my interaction with the computer was limited by the slow turnaround of using punched cards on a batch-processing computer. Then timeshared computing was developed, and this greatly improved the interaction. Microcomputers have further improved the human-machine interaction in computer program. Computer programming is now an example of highly interactive computing. It is also an excellent example of a situated learning environment.

Final Remarks

Learning occurs in one's mind. This article focuses on various types of learning environments in which there is interaction between a computer system and a person's mind. Such interactive learning situations can be improved by:

1. Improving the computer system. For example, we are making progress in developing Intelligent CAI systems that have some of the characteristics of a good human tutor. There are a number of examples of computer simulations that are excellent aids to learning, but relatively few have been designed for use at the precollege level.

2. Helping the student learn to make effective use of the various types of interactivity that a computer can provide. Often this takes considerable learning on the part of the student. Situated Learning is a learning theory that fits well with immersing students into computer rich problem solving environments in a manner that will facilitate student learning.

3. Incorporating ideas from Situated Learning Theory.

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Distance Learning

This section on Distance Learning is divided into three subsections. The first is a "traditional" overview of Distance Learning. The second is more visionary (far out). The third talks about the very important concept of *bandwidth*.

Traditional Overview of Distance Learning

Distance Learning (DL) via Correspondence Courses existed long before the development of the first computers. In correspondence courses the interactivity between student and instructor was quite slow, perhaps measured in terms of several weeks for an interaction. Of course, airmail improved this situation.

DL has been conducted by one-way (broadcast) radio as well as two-way radio. It has been conducted by a combination of broadcast TV and surface or airmail. You can think of the everyday TV that people watch and radio broadcasts that people listen to as types of DL. Most of this component of DL might be classified as informal education, but some of the materials are well suited for using in formal educational settings.

In more recent times, it has become common for DL to made use of two-way TV, email, and the Web. We are gradually seeing a merger of these technologies. Thus, we are gradually moving toward the situation of DL environments based on interactive two-way audio and video being made available on the Web, and being supplemented by email, chat rooms, Web-based telephone, and so on.

As with initial research into CAL, the first issue in DL has tended to be measures of student learning via DL versus learning via other modes of instruction. There have been hundreds of such studies. Large numbers of studies have reported "no significant difference" in learning outcomes (Russell, n.d.). However, the situation is much more complex than is suggested by this type of literature.

Schools provide a social setting in which people come together and interact with each other. As students progress through years of schooling, they become used to the idea that formal education is conducted in this social setting and that the social and face-to-face interactions are a key part of schooling. This environment (think in terms of situated learning) is a very powerful component of formal education.

Many students who are put into DL environments do not become adequately engaged to do the coursework. They lack the wherewithal of intrinsic and extrinsic motivation to keep them seriously engaged in the necessary learning tasks. Thus, many different DL courses have experienced drop out rates and non-completion of 50% or more. Most often the drop out and non-completing students are lumped together for statistical purposes. Both groups are counted as drop outs, and they are not figured into the "learning" effectiveness of the course. Thus, most studies that report "no significant difference" exclude a significant percentage of the students who begin the course.

Lynn Lary is currently the Technology Coordinator for the Lane Educational Service District located in Oregon. Her doctorate dissertation on Distance Learning provides a good overview of the field (Lary, 2002).

The use of DL at the precollege level is steadily growing. The quality of the courses, the screening of potential students, the design to help students who might otherwise drop out, and other improvements are increasing completion rates. Internet II is steadily making progress. It provides a thousand or times the bandwidth of our currently widely used Internet (which can be called Internet I). Internet II makes possible high bandwidth interactive TV along with other telecommunication capabilities that enhance communication. Distance Education will be a steadily growing component of both formal and informal education systems for many years to come.

Visionary (Far Out) View of Distance Learning

Learning takes place within a learner's body (which includes the brain) and mind. The content to be learned comes from within the mind/body and from outside the mind/body. For example, I can consciously think about a topic, come up with some ideas that I feel are important, and remember (learn) the ideas. All of this takes place within my mind/body. Or, I can read a book can construct understanding and knowledge of some of its content. The learning takes place within my mind/body, but I draw upon resources both with and outside of my mind/body.

Now, consider the nature of the external (outside the mind/body) aids to learning. I have mentioned books. Other resources include teachers, TV, friends, the environments, and so on.

My mind/body interacts with these external resources. Much of this interaction occurs at a subconscious level, with the mind not being aware of it. Learning can occur through this subconscious interaction. However, formal education systems (such as schools) tend to focus their attention on creating environments in which conscious, considered learning occurs.

The schooling-oriented aids to learning are all exterior to the mind/brain. Thus, in some sense all school-based education can be considered as Distance Learning. Let's think about this in greater depth. Consider a schooling situation in which the learner has a team of private tutors. Each tutor is highly skilled and each knows one or more disciplines in both breadth and depth. Each is a human being and has good communication skills. Each comes to know a considerable amount about the learner—especially those aspects of the learner that are relevant to learning the topic areas being taught by the tutor. The tutors have large libraries of resources materials 9books, videos, and so on) that they can make available to the learner. In addition to all of this, the tutors and this teaching situation have sufficient funds to take the learner on trips, immerse the learner in various learning environments (such as within the culture and language of various countries), and so on.

This situation is sometimes called the "gold standard" for teaching/learning. The term "gold standard" is meant to suggest that this is about as good as can be created—rather than suggesting that it is very expensive. Very few people experience such a high quality education.

Figure 6.3 is an External Learning Environment scale. It can be used to discuss our "conventional" and various efforts to make improvements in a cost effective manner.
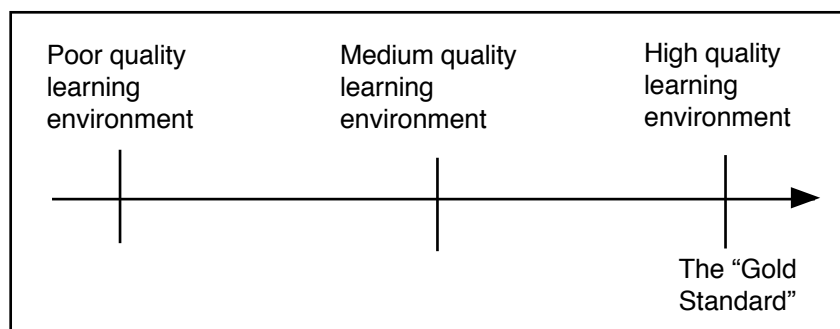
Figure 6.3. Scale representing external learning environments.

It is possible to analyze various components of an external learning. We know, for example, that school should be a safe place, that students need to have adequate food, clothing and shelter, and so on. But, let's move beyond these essentials. We know that each student is unique and that each student has unique learning abilities. We understand constructivism, intrinsic motivation, extrinsic motivation, and situation learning. Thus, we try to design the school-based learning environments so that they accommodate the various needs, abilities, and interests of the students.

Distance Learning via ICT adds a new component to the external learning environments that we can create. Here are a few examples of such Distance Learning from the broad point of view of this sub section:

- Interactive talking toys and books.
- Electronic books.
- The "help" features built into applications software, computer games, and so on.

- The aids to solving problems and accomplishing tasks built into software tools. For example, the spelling checker, grammar checker, dictionary, and thesaurus available in a full-feature word processor are all aids to learning.

- Aids to communication such as cellular telephones and email.

- The Web, considered as a global library.

- Computer-assisted learning—the full range, from simple-minded drill and practice to sophisticated simulations, perhaps occurring in a virtual reality environment.

- The synchronous and asynchronous types of Distance learning discussed in the previous sub section. These vary in length from a few seconds of tutorial on a specific small topic to full featured, full length courses.

With this broad view of Distance Learning, ICT is already a significant component of the external learning environment. It will continue to increase in importance.

To close this sub section, I want to make a final comment about the "gold standard." We already have some highly-interactive intelligent computer-assisted learning that is better than human tutors in a variety of learning situation. For example, the airplane pilot flight simulators allow pilots to experience and learn about a wide range of emergencies in a manner that is more effective and much safer than can be provided through the use of a human tutor and flying in a real airplane. Not only is ICT-based DL "here to stay," it will continue to become more and more important.

Bandwidth

My mental model for traditional ICT-based asynchronous and synchronous Distance Learning is a person making use of a networked computer. The network connects the learner's computer to other computers, and the speed (the bandwidth) of the connectivity is quite important. It takes only a modest bandwidth to provide interactive text. But it takes a quite high bandwidth to work with high quality video.

Term *bandwidth* is most often used in discussions of the number of bits per second or bytes per second that can be carried over some telecommunications channel. For example, a modem in a computer might be rated as a 56K modem. This means that it can transmit and receive 56K bits per second, assuming that the wireless or wired connectivity can handle such a speed. A byte is eight bits, and can be used to code a collection of 256 characters (2 to the 8th is 256), like those found on a computer keyboard. When computer people use the symbol K, they usually mean "2 to the 10th" which is 1,024.

A megabyte is 2 to the 20th bytes, which is 1,048,576 bytes. Roughly speaking, a medium-length novel that does not include pictures is about a megabyte in length. For most purposes it is okay to think of a kilobyte (KB) as a thousand bytes, and a megabyte (MB) as a million bytes.

Suppose that you are using a 56K modem and you want to download a medium length novel that does not contain pictures. Then it will take roughly two and a half minutes. That is not too long if your intent is then to read the entire novel.

Now suppose that you are interested in viewing a high quality photograph of a painting. The computer display screen I am currently using is set at a resolution of 1,024 by 768 pixels, and it is set a "thousands of colors." What this means is that one full-screen picture is 1,024 x 768 x 2 x 8 = 1,114,112 bits of information. (The "2" and the "8" come from the two bytes needed to code

the thousands of possible colors in one pixel.) This means that it takes about 20 seconds to download one such picture to my computer using a 56K modem.

But, let's further complicate the situation. What I really want to do is view a high quality video. That is, I want to look at a video that is 30 frames per second, and the quality of the frames is to be the quality of the individual picture discussed in the previous paragraph. This means that it will take about 10 minutes to download one second of this video if I use my 56K modem. Now you can begin to see why much higher bandwidths are desirable!

The discussion so far in this sub section focuses on the bandwidth between a learner's computer and a computer system that is being used to provide the Distance Learning content. Now let's take the same ideas and apply them to the communication channel between a human teacher and a class of students. The teacher continually "broadcasts" a multimedia "program" that can be thought of as consisting of very high quality video (e.g., the teacher, the classroom, the teacher moving about the classroom), audio (e.g., the teacher talking), smells (e.g., perhaps deodorant and perfume), and touch (perhaps the teacher touches a student). Perhaps the teacher provides the students with something to taste, for example in a science lesson on sweet and sour. All of the students in the room contribute to and are an integral part of this multimedia performance.

The teacher and the students are processing a very high bandwidth of information that they receive through their senses. Each does the processing using body and mind—a very powerful processing system. Each is continually making conscious and subconscious decisions as to where to focus attention and what to do with the huge amount of incoming data. Each is sending and receiving data from the point of view of being an intelligent human being.

I find it interesting to think about the face-to-face, human-to-human interface and interaction versus the computer system to human interface and interaction. The later is steadily improving through the development of higher bandwidth communication systems, virtual reality systems, and more intelligent and knowledgeable computer systems. I enjoy watching Star Trek television programs and movies, and I especially enjoy the Holodeck, which is a very sophisticated highly intelligent virtual reality system. Today's frontiers of highly interactive, intelligent, virtual reality systems have a long way to go before they begin to compare favorably with the Holodeck of science fiction. But…significant progress is occurring! The future of ICT-based Distance Learning is very bright!

Final Remarks on Chapter 6 Topics

Our formal educational system of schools and schooling is a huge and slowly changing social system. ICT, including CAL and DL, are a powerful change agent. Now and in the future it will be interesting to watch the collision of the slow to change formal educational system and the powerful change agent.

If you are a relatively young inservice or preservice teacher, you will have 20 to 30 years or more of involvement in this collision. During this time ICT systems will grow immensely in capability. CAL and DL will get better and better. During your teaching career you will see significant changes in our formal education system brought on by CAL and DL.

Activities for Chapter 6

1. Explore your thoughts and feelings about the fact that in certain limited teaching and learning situations, HIICAL produces results that are better than what an average teacher produces when working with a classroom of students.

2. Explore your thoughts and feelings about the fact that in certain limited teaching and learning situations, HIICAL produces results that are better than what an average individual tutor produces when working with a student.

3. Gradually, quite a bit of the HIICAL named in (1) and (2) given above will become available (at a reasonable cost) to students at home, to Libraries, to Home Schools, to Charter Schools, to Private Schools, and to Public Schools. What are your thoughts and feelings as to how this will change the teaching profession and your career as a teacher? In your thinking, give consideration to ideas of individualization of instruction and constructivism.

4. Explore and share your thoughts about the future of ICT as an aid to teaching and learning as the Holodeck-like features of intelligent, highly interactive, virtual reality systems continue to be improved and their costs continue to decline.

5. Think about the numbers and mathematics used in discussion bandwidth. From your point of view, how relevant was this subsection of the book to the overall goal you have of being an effective ICT-using educator/

Chapter 7

ICT in Assessment and Accountability

> "I hear and I forget. I see and I remember. I do and I understand." (Confucius)
>
> "When I examine myself and my methods of thought, I come to the conclusion that the gift of fantasy has meant more to me than my talent for absorbing positive knowledge." (Albert Einstein)

ICT is now a widely used aid to student assessment. In addition, the introduction of ICT into school curricula has brought with it the need to assess student learning of ICT. Finally, self-assessment is of growing importance in education, and ICT can play a significant role in it.

There are a variety of ways to look at assessment. For example, we can ask if an assessment instrument or an assessment system is reliable, valid, fair, authentic, and cost effective. We can ask if an assessment system provides appropriate help to students, teachers, and others in improving our educational system. We can ask if an assessment system contributes to accountability. This chapter discusses such issues from an ICT point of view.

Overview of General Background Information

Most preservice teacher education programs include a course that specifically focuses on assessment, evaluation, and related topics. The reference (ETSU, n.d.) provides links to a large number of articles of possible interest to preservice and inservice teachers.

The Overview of General Background Information part of the current chapter summarizes a few of the key ideas that might be covered in an introductory course on assessment. In this part of the chapter, there is little specific mention of ICT.

Assessment and Evaluation

People often confuse the two terms, **assessment** and **evaluation.** Quoting from Brookhart (1999):

> "Assessment" means to gather and interpret information about students' achievement, and "achievement" means the level of attainment of learning goals … Assessing students' achievement is generally accomplished through tests, classroom and take-home assignments, and assigned projects. **Strictly speaking, "assessment" refers to assignments and tasks that provide information, and "evaluation" refers to judgments based on that information.** [Bold added for emphasis.]

In brief, assessment is the process of gathering data about performance, and evaluation is the analysis and the assigning of meaning and value to the assessment data.

Some aspects of assessment can be automated through use of ICT. ICT also can play a significant role in evaluation. However, human judgment is a key aspect of evaluation in education, so this is a situation in which one seeks an appropriate balance between human and ICT system capabilities in accomplishing the task.

Norm Referenced and Criterion Referenced Evaluating

State and national evaluation of student performance often involves comparing students against criteria (criterion referenced) or other students (norm referenced). The following two

definitions come from the Center for the Study of Evaluation glossary (CSE http://www.cse.ucla.edu/resources/glossary_set.htm).

> Criterion-Referenced Assessment. An assessment where an individual's performance is compared to a specific learning objective or performance standard and not to the performance of other students. Criterion-referenced assessment tells us how well students are performing on specific goals or standards rather that just telling how their performance compares to a norm group of students nationally or locally. In criterion-referenced assessments, it is possible that none, or all, of the examinees will reach a particular goal or performance standard. For example: "all of the students demonstrated proficiency in applying concepts from astronomy, meteorology, geology, oceanography, and physics to describe the forces that shape the earth."

> Norm-Referenced Assessment. An assessment where student performance or performances are compared to a larger group. Usually the larger group or "norm group" is a national sample representing a wide and diverse cross-section of students. Students, schools, districts, and even states are compared or rank-ordered in relation to the norm group. The purpose of a norm-referenced assessment is usually to sort students and not to measure achievement towards some criterion of performance.

ICT has contributed to the development and use of huge amounts of assessment data for the purposes of developing norm-referenced assessment instruments. The judgment of human experts in a field is a key aspect of developing criterion-referenced assessment instruments.

Formative, Summative, and Residual Impact Evaluation

Evaluation is sometimes divided into three categories:

1. Formative evaluation. This is evaluation that occurs in a timely manner to allow "mid course" feedback and changes in a teaching/learning or other activity. In a teaching/learning classroom environment, such formative evaluation may result in letter or numerical grades being assigned to and reported to students. However, That is not a necessary component of formative evaluation. The key issues is providing feedback to students and the teacher in a timely manner. ICT can be useful in this endeavor.

2. Summative evaluation. This is evaluation of a teaching/learning activity or other activity that summarizes the outcomes. It may be based on a combination of assessment data garnered during the course of the activity and assessment data garnered at the end or shortly after the end of the activity. From a student point of view, reports from summative evaluation come after a unit of instruction has been completed, when it is too late for a student to make changes in his or her learning and other work activities. From a teacher point of view, summative evaluation provides information about the effectiveness of a lesson or sequence of lessons, and it provides information that can be used to improve the lessons for use sometime in the future.

3. Long-term residual impact evaluation. This is evaluation based on assessment data gathered well after a teaching/learning or other activity has ended. For example, educators are interested in the "end of the subsequent summer" residual impact of instruction that has occurred during an academic year. As a teacher, you can do some residual impact evaluation of your students a few weeks or months after a unit of study has been completed. You may be surprised by the results.

Reliable, Valid, and Fair Assessment

Researchers and practitioners in assessment agree that assessment instruments should be reliable, valid, and fair. The following two definitions come from the Center for the Study of Evaluation (CSE Glossary, n.d.).

Reliability. The degree to which the results of an assessment are dependable and consistently measure particular student knowledge and/or skills. Reliability is an indication of the consistency of scores across raters, over time, or across different tasks or items that measure the same thing. Thus, reliability may be expressed as (a) the relationship between test items intended to measure the same skill or knowledge (item reliability), (b) the relationship between two administrations of the same test to the same student or students (test/retest reliability), or (c) the degree of agreement between two or more raters (rater reliability). An unreliable assessment cannot be valid.

Validity. The extent to which an assessment measures what it is supposed to measure and the extent to which inferences and actions made on the basis of test scores are appropriate and accurate. For example, if a student performs well on a reading test, how confident are we that that student is a good reader? A valid standards-based assessment is aligned with the standards intended to be measured, provides an accurate and reliable estimate of students' performance relative to the standard, and is fair. An assessment cannot be valid if it is not reliable.

An assessment instrument may be both reliable and valid, but may not be designed to be equally fair to various subgroups of people being assessed. The instrument may favor men over women, or different ethnic groups, or different religious groups, and so on. An assessment may favor students who have taken a specific course from a specific teacher versus students who have learned the material in other ways and/or from other teachers. An assessment instrument may favor students who have grown up in a high socio-economic setting versus students from lower socio-economic setting.

Reliability can be measured by use of a variety of statistical techniques. Validity can be determined by a careful analysis of an assessment instrument in terms of the instructional goals, instructional content, teaching methodology, and other aids to teaching and learning involved in a unit of study that is being assessed. It is much harder to determine if an assessment instrument is fair. Among other difficulties is that of deciding who the assessment instrument should be fair to.

ICT is used various aspects of administering and scoring a wide variety of assessment instruments. This, by itself, does not ensure that an assessment instrument is reliable, valid, or fair.

Accumulated Knowledge Base

Both assessment and evaluation are large and complex disciplines. They are also the basis for a very large industry. For many years there was an ERIC Clearinghouse on Assessment and Evaluation . However, Federal Funding for this endeavor ceased on Dec 19, 2003. Some of this literature is available at the site of the electronic, peer-reviewed journal. *Practical Assessment, Evaluation, and Review* (n.d.).

There is a substantial and steadily growing research base of knowledge in assessment and evaluation. A good source of information on this research is the UCLA Center for the Study of Evaluation. (CSE, n.d.). Quoting from the Website:

For more than 36 years, the UCLA Center for the Study of Evaluation (CSE) and, more recently, the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) have been on the forefront of efforts to improve the quality of education and learning in America. …

In recent years, CSE/CRESST has grown to meet expanded needs resulting from changes in federal and state laws and has substantially broadened its research well beyond the K-12 educator audience. Through the addition of several new projects, CSE/CRESST research and development now extends significantly into pre-school and after-school programs and also includes studies of adult learning using advanced technology.

Teachers, school districts, and our overall educational system make use of a variety of assessment instruments. These vary widely in quality and how well they support evaluation needs. Moreover, there are ongoing efforts to improve assessment. One approach is through the use of Alternative Assessment instruments and procedures.

Alternative Assessment

The remainder of this chapter focuses on topics that are particularly relevant to ICT in education.

To a large extent, "traditional" assessment in the United States is based on objective tests—true/false, multiple choice, matching, and so on. Here is a definition of alternative assessment from the Center for the Study of Evaluation glossary (CSE, n.d.).

> **Alternative Assessment** (also authentic or performance assessment): An assessment that requires students to generate a response to a question rather than choose from a set of responses provided to them. Exhibitions, investigations, demonstrations, written or oral responses, journals, and **portfolios** are examples of the assessment alternatives we think of when we use the term "alternative assessment." Ideally, alternative assessment requires students to actively accomplish complex and significant tasks, while bringing to bear prior knowledge, recent learning, and relevant skills to solve realistic or authentic problems. Alternative assessments are usually one key element of an **assessment system**.

Notice the emphasis given to students accomplishing complex and significant tasks, and students solving realistic or authentic problems. As noted much earlier in this book, there is considerable agreement in goals of education that focus on students learning to solve complex problems and accomplish complex tasks. The assessment issue is how to assess this type of student learning.

In recent years, one approach has to strive to make assessment be more "authentic." Grant Wiggins has long been a leader in this approach. Quoting from Wiggins (1990):

> Assessment is authentic when we directly examine student performance on worthy intellectual tasks. Traditional assessment, by contract, relies on indirect or proxy 'items'—efficient, simplistic substitutes from which we think valid inferences can be made about the student's performance at those valued challenges.

The key idea is the issue of assessment that uses indirect or proxy items versus assessment that directly examines student performance on "worthy intellectual tasks. For example, suppose that we want to assess how well a student can write in a word processing environment. We could analyze this assessment task and decide we should give the student a two-part test. The first part would be a paper and pencil writing task—perhaps writing a 200-word essay on a specified topic. This would be graded in a "traditional" manner that includes emphasis on spelling, punctuation, legibility, content, and so on. The second part would be an objective test on various aspects of a word processor, including where the on-off switch is located on a particular machine, how to load paper into a printer, what commands are used to load and save a file, and so on.

This above example is mean to sound ridiculous. It emphasizes a far extreme from authentic assessment. Contrast this with simply seating the student at a computer and asking the student to make use of the computer to write, edit, save, and print out a 200-word essay. You might observe the student carrying out this task, looking for effective use of a word processor as an aid to process writing (revise, revise, revise), spelling, certain aspects of grammar, and counting words. You would note whether the student appropriately saves the document from time to time and knows how to print a document. In additional to the assessment information you gained through observations, you would read the document of content and overall (holistic) quality of writing.

Typically, there is a reasonable amount of authenticity in traditional modes of assessment. However, the following additional quotations from Wiggins (1990) emphasize how authentic assessment differs from traditional assessment.

Authentic assessments attend to whether the student can craft polished, thorough and justifiable answers, performances or products. Conventional tests typically only ask the student to select or write correct responses—irrespective of reasons. (There is rarely an adequate opportunity to plan, revise and substantiate responses on typical tests, even when there are open-ended questions).

…

Authentic tasks involve "ill-structured" challenges and roles that help students rehearse for the complex ambiguities of the "game" of adult and professional life. Traditional tests are more like drills, assessing static and too-often arbitrarily discrete or simplistic elements of those activities.

Authentic assessment is an important idea throughout all of education. ICT brings new challenges of authentic assessment of student knowledge and skills related to ICT or making use of ICT as students demonstrate knowledge and skill in non-ICT areas. Think, for a moment, about the working environment of a typical white-collar worker nowadays. Of course, the worker has a telephone. This person also has an Internet-connected computer sitting on his or her desk, available for use on any work task that can benefit from the types of tools that ICT provides. This person learns to use ICT as a routine aid to solving problems, accomplishing tasks, producing reports, and so on.

Now, contrast this with how we currently assess students who are in school. Very few teachers think it would be all right to provide students routine access to a computer, email, the Web, and a cell telephone while taking tests. Teachers talk about preparing students for adult life and jobs in our society. But, the assessment system used in schools is not authentic relative to adult life and jobs.

The function of school is not to help kids do well in school. The function of school is to help kids do well in life. (Elliot Eisner, Professor of Education, Stanford University)

The problems of life are much more like the problems encountered in the arts. They are problems that seldom have a single correct solution; they are problems that are often subtle, occasionally ambiguous, and sometimes dilemma-like. One would think that schools that wanted to prepare students for life would employ tasks and problems similar to those found outside of schools. This is hardly the case. Life outside of school is seldom like school assignments--and hardly ever like a multiple-choice test. - from Elliot Eisner's book, *The Kind of Schools We Need*

Nationwide and Statewide Assessment in ICT

Student learning in the discipline of ICT and in the applications of ICT throughout the curriculum have not yet been subjected to rigorous nation-wide assessment. Thus, there is no firm basis for either criterion-referenced or norm-referenced assessment in these areas for precollege students. However, some states and provinces, both in the United States and elsewhere, have tackled the problem of assessment of students in ICT and its applications.

For example, Leete (2003), discusses such assessment in New South Wales, Australia. Her document argues against the currently proposed implementation of such assessment because the curriculum has not been adequately developed and the teachers have not been adequately trained. The following list of areas to be assessed is quoted from her document:

The 10 competencies that are to be covered across the subject areas are:

1. Operate effectively within the desktop environment.

2. Perform basic operations within computer software packages.

3. Perform core tasks common to software applications.

4. Demonstrate basic word-processing skills as they create, work with and modify text documents.

5. Demonstrate basic spreadsheet skills as they create, work with and modify files.

6. Demonstrate basic database skills to create, work with and modify files.

7. Demonstrate basic multimedia skills to create, work with and modify multimedia-based files.

8. Demonstrate basic graphics skills to create, work with and modify images.

9. Conduct research using information and communication technologies.

10. Demonstrate internet/intranet communication skills, including use of email.

You will notice that there is no emphasis on problem solving and other higher-order cognition in this list. Thus, from my point of view, this is an inadequate instrument.

North Carolina has implemented a statewide test that is required for graduation and that is first administered in the 8th grade (NC Public Schools, n.d.). From the NC Public Schools Website one can access The Report of Student Performance on the North Carolina Tests of Computer Skills: 2001-02 (Acrobat 2.6 MB). And, within that report one can access sample questions used in the assessment. (The Table of Contents titles are clickable.)

The test consists of a combination of multiple choice and hands-on questions designed to be administered entirely in a hands-on computer mode. The following (accessed 12/15/04) is quoted from http://www.ncpublicschools.org/accountability/testing/computerskills/handbook/.

North Carolina

Tests of Computer Skills

(Graduation Requirement)

Student Handbooks

Information in both student handbooks, including sample test items, electronic files, etc. must not be used for personal or financial gain. North Carolina LEA/school officials, teachers, parents, and students may download and duplicate the handbooks and electronic files for instructional and educational purposes only. Others may not duplicate the handbooks without prior written permission from the NCDPI Division of Accountability Services/Testing Section.

*   ***The North Carolina Tests of Computer Skills Student Handbook (For Students Who Entered Grade 8 in the 2000-2001 School Year and Beyond)***, Published June 2002. This handbook for students explains the Tests of Computer Skills and provides sample questions and preparation strategies. This handbook contains sample items for the revised computer skills multiple-choice and performance tests.

Here are several sample questions quoted from that document:

1. Trish is editing the last paragraph of her essay. She has decided to add another sentence before the last sentence. Which of the following would be the ***most efficient*** process?

    A Type the sentence in another document and then place it in her essay where she wants it.

    B Type the sentence at the end of her essay and then move it to where she wants it.

    C Type the sentence at the end of her essay, copy the new sentence, and then paste it where she wants it.

    D Put the cursor at the point where she wants to add the sentence and then type the sentence.

2. Which search of an electronic phone directory would find only the Doe families living on Main Street in area code 919?

    A   Name = "Doe" or Address = "Main Street" or Area Code = "919"

    B   Name = "Doe" and Address = "Main Street" or Area Code = "919"

    C   Name = "Doe" or Address = "Main Street" and Area Code = "919"

    D   Name = "Doe" and Address = "Main Street" and Area Code = "919"

5. Why is a web site an effective way to present a report on an animal that you are studying?

    A   People like to read reports on computers.

    B   People can follow links to additional information, pictures, or animal sounds.

    C   People do not have to read the report; they can just look at the pictures and listen to the sounds.

    D   People can read a long report on one page by scrolling down so they do not have to go to another web page.

7. Which method is used to cite resource materials in multimedia projects?

    A   bibliography of print resources

    B   bibliography of three main sources

    C   bibliography of online resources only

    D   bibliography of all resources

One of the hands-on components of the assessment is on use of a word processor. Students are given a word processor document in electronic form. The directions are:

1. Center the newsletter title, *The Social Studies TV Project Update*, in bold 24-point type.

2. In the first article, *The Big Four Became the Big Three*, make the following edits:

    •   Center the title in bold 14-point type

    •   Single space and left-align the text in regular 12-point type

    •   Indent the paragraph

3. In the second article, TV Study to Be Televised, italicize the title, The Social Effects of Television in 1958.

4. Use the spell checker to make certain all words are spelled correctly.

5. Below the last article, type the following article: Paying for Noticeable Names. [[Note to reader: A short article is provided to be typed in.]] Remember to:

    •   Key as accurately as possible the title and paragraphs in the box below

    •   Center and format the title in bold 14-point type

    •   Indent the paragraph

    •   Left-align the text in 12-point type

    •   Use correct keyboarding techniques

    •   Use word wrap and ignore any differences between what you key and how the paragraph appear on this page

    •   Use the spell checker

Rubrics for Assessment

A rubric is a scoring tool that can be used by students (for self assessment), peers (peer assessment), teachers, and others. It lists important criteria applicable to a particular type or piece of work. It also lists varying levels of possible achievement of the criteria. Figure 7.1 gives a very general purpose, six level scoring rubric. This might be useful to the teacher, but it is not useful to the student. The student cannot use this to self-assess or to assess his/her peers.

Level	Brief Description
1: Emergent	Student displays few, if any, of the rudimentary knowledge and skills that are expected.
2: Limited	Student displays rudimentary knowledge and skills, but often requires substantial individual help and guidance.
3: Developing	Student displays a minimally adequate level of the expected knowledge and skills.
4: Capable	Student displays a functional, adequate level of the expected knowledge and skills.
5: Strong	Student displays a high level of the expected knowledge and skills.
6: Exceptional	Student displays an outstanding and creative/innovative level of the expected knowledge and skills.

Table 7.1. A generic 6-level rubric.

Table 7.2 is an adaptation of Table 7.1 to the situation of assessing student use of ICT tools while working on a project. It is a rubric that might be used when a student is producing a product such as a written report or an oral presentation accompanied by detailed handouts and supported by presentation media. Such a rubric might be useful in authentic assessment of a relatively authentic task-oriented assignment. This rubric contains considerable more detail than the rubric of Figure 7.1, but it is still has significant weaknesses.

Level	Brief Description
1: Emergent	• Selected technology tools to assist in creating the desired product that were inappropriate for the task or student is not able to operate tool. • Technology was used but not to benefit the creation of a quality product. • Technology tools were tried by the student, but the required product could not be produced. • Was unable to resolve most technological obstacles relating to the project. • Ethical and professional behavior was not shown or was inappropriately shown through lack of citations, copyright adherence, and ethics.
2: Limited	• Selected lesser effective tools from what is available to create the desired product. • Technology was used to address the tasks but few of the capabilities of the technologies were used to create the product. • Technology tools are used and set up appropriately, but only with major outside assistance. • Was able to solve only elementary technological obstacles. • Ethical and professional behavior was occasionally shown through appropriate citations, copyright adherence, and ethics.
3: Developing	• Selected appropriate tools from what was available to create the desired product, but only with outside assistance. • Technologies were used but assistance was needed for the basic capabilities of the technology to create product. • Technology tools were set up and used appropriately but required some outside assistance. • Was able to solve most basic obstacles associated with the project. • Ethical and professional behavior was generally shown through appropriate citations, copyright adherence, and ethics.
4: Capable	• Selected adequate tools from what was available and appropriate for creating the desired product. • Technology was used in an appropriate way and applied the basic capabilities of the technology to create the product. • Technology tools were set up correctly and used appropriately with minor assistance. • Was able to solve some of the technology related problems associated with the project. • Ethical and professional behavior was shown through appropriate citations, copyright adherence, and ethics.
5: Strong	• Selected quality tools from what was available that was appropriate to create quality a product. • Technology was used in appropriate ways and applied many of the features to create a quality product. • Technology tools were set up correctly and used appropriately without assistance following established guidelines. • Solved most technology related problems associated with the project. • Ethical and professional behavior was shown through appropriate citations in proper form, copyright adherence, and ethics.
6: Exceptional	• Selected the most appropriate tools from what was available, to create high quality products. • Technology was used in an innovative way to create higher quality product than assignment anticipated. • Technology tools were not only set up correctly and used appropriately but often suggestions are provided for improvement in the procedures. • Solved all technology related problems associated with the project. • Ethical and professional behavior was shown through appropriate citations in proper form, copyright adherence, and ethics.

Figure 7.2. A generic ICT tool-use rubric.

To understand some of the weaknesses in the rubric of Figure 7.2, consider a student who receives a *4-Capable* and who is looking at the details of *6-Exceptional*. How does the student know that he or she did not selected the most appropriate tools from what was available, to create

high quality products? Does the student have any idea what was not "most appropriate" among the tools that he or she selected? If the student were to redo or to spend more time on his or her product, does the feedback provided by the rubric and a rating of *4-Capabable* helpful in moving toward producing a product that would be *5-Strong* or *6-Exceptional?*

The brief discussion of the rubrics given in Figures 7.1 and 7.2 helps to emphasize the difficulty in providing evaluation that supports increased learning and improvement in the quality of work that a student is doing. A good rubric is fully understandable by the students who will be assessed. The rubric needs to be accompanied by instruction so that students can self-assess their work. Learning to self-assess one's work in a discipline is an important aspect of learning the discipline and moving up the expertise scale in the discipline.

Some people who have thought a lot about use of rubrics in assessment and have suggested that students should be involved in developing the rubrics that will be used in their assessment. Some teachers have found that this idea works well in conjunction with helping students learn what they will be assed on and how they will be assessed.

Still another set of assessment possibilities comes from the idea of computerizing (automating) certain aspects of the assessment-evaluation-feedback process. This topic is addressed in the next section.

ICT-Assisted Self-Assessment

The first part of this section focuses on self-assessment. The second part focuses on some ideas of ICT-assisted self-assessment.

Self-Assessment

You are an adult learner. Your previous education has provided you with some help in moving up a scale that reflects your knowledge and skills about assessing your own learning. Figure 7.3 represents this idea.

Expertise in Self-Assessment of My Learning

Novice: I'm just a beginner at this.

Medium: I have a useful level of knowledge and skills at this.

Expert: I'm very skilled and experienced at this.
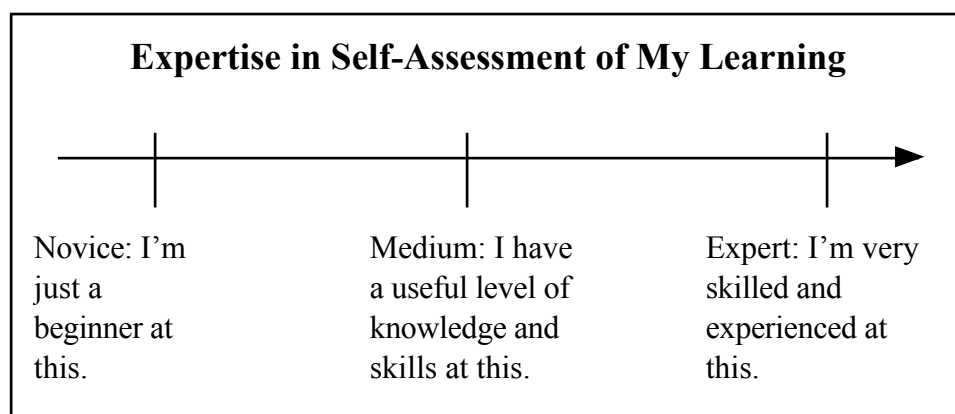
Figure 7.3. Expertise in self-assessment.

Think of yourself as a learner making use of this book to gain increased knowledge and skills in being a good teacher who makes effective use of ICT as an aid to student learning. Spend a few minutes doing metacognition on your learning of the materials in this book. Let your metacognition be guided by the following questions.

Am I learning well enough:

- so that the knowledge and skills will stay with me, for use in the future?

- to transfer the knowledge and skills to situations where and when they are applicable?

- to serve my current needs as a preservice or inservice teacher?

- so that I can build on the knowledge and skills in the future, as the field of ICT in education continues to change rapidly?

- so I have a much improved insight into what I don't know, why I might want to learn some of the things that I don't know, and pathways to doing the learning?

What are your thoughts and feelings about this metacognition exercise? Have you asked yourself such questions during some of your past learning experiences? Is there any value in asking yourself such questions?

The metacognition questions are hard questions, and the answers are quite personal to you. These types of questions closely relate to the ideas of constructivism. As an adult learner, you are able to take much more responsibility for your learning than an elementary or secondary school student can. You are more aware of what you know, what you want to know, and why you want to gain the increased knowledge and skills.

Is there value in helping your students learn to ask and answer the same kinds of questions? What might you do as a teacher to help your students increase in expertise as self-assessors of their learning?

Chapter 2 of this book contains an analysis of self-assessment of word processing and doing desktop publication in a word processing environment. You might want to review this chapter to help clarify your insights into ICT self-assessment.

The chapter contains quite a bit of detail about word processing and desktop publication. However, it is still inadequate, because it does not list a number of important a typical modern word processor. Here are three examples of shortcomings:

1. What do you know about the use details of use of Tables in a word processor? Do you know how to create and edit a table, size it to fit the data or information you are entering, format the table, and align (place) the table appropriately in your document as part of the process of preparing your document for desktop publication? Suppose that you decide that two columns of a table you have word-processed need to be interchanged. Do you know an efficient way to do this? Do you know how to import a table or table data from the Web, from a spreadsheet, and from other word-processed documents? Do you know how to export a table from a word-processed document?

2. Another characteristic of the self-assessment instrument in Chapter 2 is that it is not "automated." Contrast it with an assessment presented by computer, with the user entering responses via computer, and then the computer system "scoring" the results and providing detailed feedback to the user.

3. Still another characteristic of the self-assessment in Chapter 2 is that it is weak on authenticity. It does not ask you to actually complete various tasks on a computer.

The discussion given above provides an introduction to some of the ideas of self-assessment and of ICT-assisted self-assessment. In both cases we are particularly interested in the feedback (formative evaluation) aspects of self-assessment as an aid to the learner. A major goal is to help a person become more independent and self-sufficient as a learner and as a user of his or her

learning. In school, students become highly dependent on teachers facilitating assessment processes, and providing formative and summative evaluation feedback. This approach is weak in helping students to be able to judge the quality of their own work, knowledge, and skills. Seldom is it well integrated, in a constructivist sense, with the specific learning progress that each individual student is engaged in.

Learning to self-assess is am important and difficult goal in any unit of instruction. There is some published literature on this topic, but to me the published research and craft knowledge seems inadequate. I don't believe that our educational system is very successful in helping students learn to self-assess over the various curriculum areas that they study.

The following is quoted from Linda Bruce's Website (Bruce, n.d.):

Incorporating a standards-based approach to teaching and learning can be a creative and enriching endeavor. What's one key approach? Ask students to assess their own work.

Five teachers in a suburban high school recently implemented student self-assessment (SSA) activities in their classes. The results of this experiment—in courses as different as physics and foreign language—revealed the potential of SSA to make standards come alive for students. The reactions of students and teachers in this project also indicated that student self-assessment practices offer solutions to some of the concerns about standards that have been expressed by both supporters and opponents of this approach to school reform.

…

In general, SSA refers to training students to evaluate their own work for the purpose of improving it (Rolheiser & Ross, 2000). To become capable evaluators of their work, students must have

- a clear target
- the opportunity to help create a definition of quality work
- feedback
- the opportunity to correct or self-adjust their work before they turn it in

SSA also includes reflective activities in which students are prompted to consider the strengths and weaknesses of their work, make plans for improvement, or integrate the assignment with previous learning (Paris & Ayres, 1994; Stiggins, 1997; Wiggins, 1998).

A 12/15/04 Google search on Self-Assessment turns up over 4 million hits. Quite a few of the hits are self-assessment instruments, while very few of the hits are research results supporting either the general effectiveness of self-assessment or the reliability, validity, and fairness of the instruments that are discussed. Quite a few of the self-assessment instruments are available on and administered by the Web.

For example, the Western Governors University is a university in the in the U.S. offering competency-based, online degrees. It provides an online self-assessment instrument that a person can use to help decide whether he or she will be successful in this mode of learning (Western Governors). You might want to do a compare and contrast with some of the instruments in a list developed by the University of Illinois (Illinois Online University). You may notice, for example the varying quality of feedback or explanation provided by the various instruments.

From a teaching and learning point of view, a good self-assessment instrument provides high quality feedback designed to help the learner. Such self-assessment is a key component of good Computer-Assisted learning materials. However, it is also an important aspect of computer tools and the "Help" feature that accompanies such tools. For example, consider the spelling and grammar check in a modern word processor. As you write, these to pieces of software provide

feedback on your spelling and grammar. The feedback is both immediate and exactly focused on your writing. Clearly, such feedback is an aid to self-assessment.

Computer-Assisted Testing

The remainder of this chapter focuses specifically on roles of ICT in Assessment and Evaluation.

A Computer-Assisted Testing System can be thought of as a computer-based system that presents test questions, receives and scores the answers, produces a report for the teacher, and produces a report for the students. It is easy to take any object test such as T/F or Multiple Choice, and implement it in a Computer-Assisted Testing System.

In a Computer-Assisted Testing System, the report to the teacher may include information about the reliability of the test, an analysis of which questions were the best discriminators between students who did well and those who did poorly on the test, and other types of statistical analysis. The report to the student may give details on why a particular answer was not correct, and it might contain suggestions for where the correct answer was discussed in the assigned readings.

Often a Computer-Assisted Testing System will make use of a large databank of exam questions. Questions presented to a student might be drawn at random from this databank of questions. This creates a situation in which each student is likely to be faced with a different set of questions, and it facilitates allowing a student to take the test more than once.

Computer-Adaptive Testing

A Computer-Adaptive Testing System typically may include all of the features of a Computer-Assisted Testing System. However, there is one major difference. A Computer-Adaptive Testing System is designed to provide a student with a sequence of questions that allow the computer system to rapidly narrow in on a measure of the student's knowledge in the area being tested.

Here is a simple explanation of how this is done. The first question asked of the student is at a "middle" level of difficulty. If the student answers correctly, a somewhat harder question is asked. If the student answers incorrectly, a somewhat easier question is asked. This process is repeated until the computer system narrows in on a good estimate of the student's level of performance.

It tends to be both difficult and expensive to develop a valid, reliable, and fair Computer-Adaptive Test. You can see this by thinking about how you might develop test questions in a particular discipline area. You need to rank the questions in terms of difficulty. Suppose, for example, you are making up social science questions designed for a Computer Adaptive Test to be used with fifth grade students. Then you would need to develop questions that span a wide range of difficulty—perhaps from first grade level to ninth grade level, or higher. The level of difficulty of a question depends on what the student has been taught by you, by previous teachers, and many other factors.

Note: There is now quite a bit of literature on Computer Adaptive Testing. I got nearly a million hits when I searched using this term on 12/14/04. Rudner (1998) contains a computer-based tutorial (an example of CAL) on Computer Adaptive Testing. Computer Adaptive Testing is now widely used in testing at the national level. Its use is rapidly spreading to the state and individual school district levels.

Accountability

At the current time, the public PreK-12 school system in the United States is spending a little more than two-percent of its budget on instructional uses of computers. While two-percent sounds like a small percentage, this translates into about $7 billion per year. Many people have asked if these funds are being wisely spent. They want to see solid evidence that such instructional use of ICT is improving the education being received by our students. They view this as an accountability question.

Accountability is closely related to assessment and evaluation. Suppose that certain groups of students, or schools, or school districts perform poorly relative to some set of expectations. Then people ask the question, "who is responsible (accountable) for this, and what are they going to do about it?"

In education, there are many different stakeholder groups such as students, teachers, school administrators, school boards, parents, taxpayers, legislators at a state and national level, state governors, and so on. Each stakeholder group has its own views of the goals of education and how to assess and evaluate progress toward meeting these goals. Each stakeholder group talks in terms of accountability—which usually means holding some group other than themselves accountable or responsible for the outcomes that are being achieved.

This situation is made still more complex because different stakeholders have different goals; different analyses of assessment data and information will lead to different results. Without too much effort, essentially every school can be made to look like it a seriously deficient from some point of view.

You may detect a certain amount of tongue in cheek cynicism in the previous paragraphs. A stakeholder group could also assess and evaluate itself, and determine if it is meeting its accountability responsibilities. While that does happen occasionally in education, the more common occurrence is for one group to attempt to place blame on others. For example, many groups like to point to the poor performance of students living in core city areas. However, it is not a teacher's fault if most of his or her students come from low socioeconomic neighborhoods that include many poor home situations. But we know that such student backgrounds are a quite accurate predictor of future difficulty in school and in doing well on statewide assessments.

As a current or future teacher, you are well aware of the current political aspects of accountability in education. You may not like some aspects of the significantly increased emphasis on accountability that has occurred in recent years. You may think that it is inappropriate to spend a lot of teacher and student time preparing for state and national assessment.

Regardless of your position on such accountability issues, you have a high level of personal responsibility (accountability to yourself) to be as good a teacher as you can be. A short paper by Lee Shulman (2003), President of the Carnegie Foundation for the advancement of Education, begins by discussing good or not good Samaritans who stop and offer assistance at an accident (or, just drive on by.) He then says:

> My point is that excellent teaching, like excellent medical care, is not simply a matter of knowing the latest techniques and technologies. Excellence also entails an ethical and moral commitment—what I might call the "pedagogical imperative." Teachers with this kind of integrity feel an obligation to not just drive by. They stop and help. They inquire into the consequences of their work with students. This is an obligation that devolves on individual faculty members, on programs, on institutions, and even on disciplinary communities. A professional actively takes responsibility; she does not wait to be held accountable.

I am assuming that you have read the preceding chapters of this book. Thus, you now have relatively good insight into quite a range of ways in which ICT can be used to improve education. If you are a preservice teacher, pay careful attention to ICT use the next time you visit a school. If you are an inservice teacher, introspect and then open your eyes, and take a careful look at how ICT is being used by you and your fellow teachers. In either case, there is a good chance that you will be disappointed by what you see. On average, the ICT facilities that are available to students in school, at home, and in other locations are not being used nearly as well as they could be used to further the education of students (Moursund's "Arguments Against" Website, n.d.).

The reasons for this are many and varied. Many of the reasons are beyond your personal control. However, many of the reasons have to do with what individual teachers are doing or not doing. You, personally, have individual accountability for yourself. Work to be an exemplar of effective use of ICT in education!

Activities for Chapter 7

1. Pretend you are talking to a parent, and the parent asks about accountability for the large amounts of money that are being spent on ICT in education. Summarize what you would say.

2. Do some self-assessment on your ICT knowledge and skills by making use of the sample questions at North Carolina's Website http://www.dpi.state.nc.us/accountability/testing/reports/. Summarize your thoughts and feelings about your performance on these 8th grade questions.

3. Select a course or grade level that you teach or are preparing to teach. Suppose that it is the beginning of a school year and you have a new class of students. How would you determine their ICT knowledge and skills that are relevant to the uses you want to make of ICT with this class? In responding to this question, be relatively specific. Thus, for example, you might want to make a list of the prerequisite knowledge and skills you would like your students to have, and figure out how you will determine whether they actually meet these prerequisites.

4. Analyze your answers to (3) from the point of view of your assessment being valid, reliable, fair, and authentic.

5. The Website Accessed 12/15/04: http://web.tickle.com/tests/uiq/ contains an IQ test designed for self-assessment. If you follow the instructions carefully, you will take a 40 question IQ test and the Website will provide you with its estimate of your IQ. If you decide to use this Website, please note that they are also trying to sell you some services. You do not need to make a purchase in order to take the test and receive their estimate of your IQ. Analyze your thinking about the availability of such a "service."

Chapter 8

ICT in Special and Gifted Education

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)

I trust the time is coming, when the occupation of an instructor to children will be deemed the most honorable of human employment. (Angelina Grimke)

This chapter addresses ICT in Special Education and ICT in Talented & Gifted Education (TAG) as two separate topics. Of course, the topics overlap, and both are often included under the title *Special Education*. Many children have two or more exceptionalities, and may well be both TAG and Special Education. Very roughly speaking, approximately 5 to 10 percent of students fit various definitions of TAG and approximately 10 to 20 percent fit various definitions of special education. Joan Coffin estimates the figure is 20 percent (Coffin, n.d.).

In 2003, about 6.2 million children (about 11.5% of public school enrollment) received special education services through federally supported programs. Of course, this figure does not include students who might well meet the conditions to be receiving federal aid, but are not receiving aid. And, the figure does not include students who have handicapping conditions that are not on the federal list. For example, a student may have a less sever form of one of the handicapping conditions covered under Federal Law 94-142, but still sufficiently severe to present major challenges to the student. Or, a child may have a handicapping condition not covered under the federal law.

Advice to Preservice and Inservice Teachers

A general education teacher can ordinarily expect to have both Special Education and TAG students in his or her classes. Thus, a general education teacher needs to know how to be a good teacher in working with and meeting the needs of a highly diverse set of students. This chapter provides an overview of some of the roles of ICT in working with Special Education and TAG students.

A key issue to keep in mind as you read this chapter is summarized by the following quote from Computer Technology and Autism (1994):

… Instead of asking the following question: "How can I use computer technology at my disposal to help this particular handicapped person?", the problem ought to be tackled in a diametrically opposite manner, with the question being asked as follows: "I have before me a person whose handicap causes some difficulty. In light of what we know about this person and of his/her handicap, is there any way of helping him/her with the use of computer aided technology?"

This approach, which is based on the person and not on available technology, may lead to direct aids for the handicapped person or indirect aids for those working with the handicapped person. One becomes fairly rapidly aware of the obvious interaction and complementarity between these two ways of assisting the handicapped person. The computer aided technology may involve various fields. Taking autism as an example, the following fields will have to be looked at:

• assistance with the diagnosis,

• assessment of learning skills,

- computer aided teaching,

- assistance in communication and finally

- the development of research models for progress in the understanding of autism.

Exceptionalities

Many people tend to 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.

What is an exceptionality? This is a complex question. It can be addressed from a legal point of view by stating what the laws, rules, and regulations say at the federal, state, and school district levels. It can be defined in terms of deviation from the mean on various measures. It can be defined in terms of an individual student attempting to accommodate to a specific school setting.

One possible starting point in thinking about exceptionalities is to think about the complexity of a persons mind and physical body. A typical human brain contains more than 100 billion neurons and more than a trillion cells. A brain has a high level of plasticity and is constantly being changed as it receives and processes inputs and as it learns. Even identical twins that have been raised together have significant differences in their brains. This type of approach to thinking about exceptionalities might lead to a conclusion that every student has significant exceptionalities.

Internal, Personal Accommodations

However, the plasticity and intelligence of a typical person's brain facilitates the development of internal and personal accommodations that overcome or circumvent a large number of problems that might be considered to be disabilities. Thus, we tend to talk about disabilities only when they are so severe that a person cannot readily accommodate to them on his or her own.

As a personal example, I am not very good at spelling. When I had to write essays in class as part of a Freshman English Composition course, I had to carefully plan my sentences so that they did not include words I could not spell correctly. In addition, my handwriting left much to be desired. I struggled in such "real time" assessments, but I was smart enough to circumvent my spelling difficulties. Fortunately, much of the grade in the course was based on weekly writing assignments that were done outside of class. There, I could make use of a dictionary and I could put in the time needed to show that I could write reasonably well. Now, of course, I use a word processor with a good spelling checker. This computer-based accommodation is a powerful "equalizer" when it comes to my spelling and handwriting.

Dual and Multiple Exceptionalities

Another major flaw in the three-part (disabled, normal, TAG) model is that many students have two or more exceptionalities. For example, a child may be both severely dyslexic and brilliant. Quoting from an ERIC Digest (Dual Exceptionalities, 1999):

Gifted students with disabling conditions remain a major group of underserved and understimulated youth (Cline, 1999). The focus on accommodations for their disabilities may preclude the recognition and development of their cognitive abilities. It is not unexpected, then, to find a significant discrepancy between the measured academic potential of these students and their actual performance in the classroom (Whitmore & Maker, 1985). In order for these children to reach their potential, it is imperative that their

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intellectual strengths be recognized and nurtured, at the same time as their disability is accommodated appropriately.

Exceptionalities and Minority Students

Special education and TAG education systems in our country have not done well in meeting the needs of minority students. Quoting from the book *Minority Students in Special and Gifted Education* by Donovan and Christoper (2002):

> Special education and gifted and talented programs were designed for children whose educational needs are not well met in regular classrooms. From their inceptions, these programs have had disproportionate representation of racial and ethnic minority students. What causes this disproportion? Is it a problem?

> *Minority Students in Special and Gifted Education* considers possible contributors to that disparity, including early biological and environmental influences and inequities in opportunities for preschool and K-12 education, as well as the possibilities of bias in the referral and assessment system that leads to placement in special programs. It examines the data on early childhood experience, on differences in educational opportunity, and on referral and placement. The book also considers whether disproportionate representation should be considered a problem. Do special education programs provide valuable educational services, or do they set students off on a path of lower educational expectations? Would students not now placed in gifted and talented programs benefit from raised expectations, more rigorous classes, and the gifted label, or would they suffer failure in classes for which they are unprepared?

As a preservice or inservice teacher you want to do your best in meeting the individual needs of each of your students. As you gain in knowledge and skills (as you move up the "good teacher expertise scale") you will get better at dealing better with a wide range of exceptionalities and with different levels or degrees of these exceptionalities. You will also get better an knowing when you need the help of experts who have more training and experience than you in dealing with specific types of exceptionalities.

A Few Assistive Technology Success Stories

Assistive technology is defined by the 1997 Individuals with Disabilities Education Act as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of children with disabilities." (IDEA)

ICT plays a major role in the field of assistive technologies. This section contains a few examples of progress in assistive technologies that have made substantial contributions to the lives of a great many people.

Kurzweil Reading Machine for the Blind

An excellent and compelling application of ICT for blind students was developed by Ray Kurzweil somewhat over 20 years ago. The Kurzweil reading machine could "read" text using a computer scanner, and "speak" the text as output. Initially it was a bulky, $50,000 device. Technological progress in the past two decade has led to handheld scanning devices costing well under $500 that can read and speak text. Kurzweil is a prolific researcher, inventor, and writer (KurzweilAI.Net).

Steven Hawking and ALS (Lou Gehrig Disease)

Steven Hawking, born in 1942, has been a worldwide role model of computer-based communication aids for people with severe speech communication disabilities. Hawking has Amyotrophic Lateral Sclerosis (ALS). ALS is a relatively rare (approximately one in 50,000 people) neurodegenerative disease that attacks nerve cells and pathways in the brain and spinal

cord. As these cells die, voluntary muscle control and movement dies with them. Patients in the later stages of ALS are totally paralyzed, yet in most cases, their minds remain sharp and alert (ALS).

You can learn more about Steven Hawking by visiting his Website (Hawking). Quoting Hawking:

> 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.

> It was a great shock to me to discover that I had motor neurone disease. I had never been very well co-ordinated physically as a child. I was not good at ball games, and my handwriting was the despair of my teachers. Maybe for this reason, I didn't care much for sport or physical activities. But things seemed to change when I went to Oxford, at the age of 17. I took up coxing and rowing. I was not Boat Race standard, but I got by at the level of inter-College competition.

> In my third year at Oxford, however, I noticed that I seemed to be getting more clumsy, and I fell over once or twice for no apparent reason. But it was not until I was at Cambridge, in the following year, that my father noticed, and took me to the family doctor. He referred me to a specialist, and shortly after my 21st birthday, I went into hospital for tests. I was in for two weeks, during which I had a wide variety of tests. They took a muscle sample from my arm, stuck electrodes into me, and injected some radio opaque fluid into my spine, and watched it going up and down with x-rays, as they tilted the bed. After all that, they didn't tell me what I had, except that it was not multiple sclerosis, and that I was an a-typical case. I gathered, however, that they expected it to continue to get worse, and that there was nothing they could do, except give me vitamins. I could see that they didn't expect them to have much effect. I didn't feel like asking for more details, because they were obviously bad.

Cochlear Implant

A large number of people are severely hearing impaired. People with severe to profound hearing loss are often called "deaf." In the United States as a whole, perhaps one in 500 to one in 1,000 people fall into this category. However, the percentages are much smaller for school age children, since "senior citizens" have a much higher than average number of cases of severe to profound hearing impairment.

The cochlear implant has restored some hearing capability to a number of deaf people. The following quote helps to provide insight into problems faces by a child with a cochlear implant and the child's teachers, fellow students, and school (Franklin, n.d.).

> On a personal level, I was exposed to the challenges of hearing loss when, at the age of three, our granddaughter, Nicole, was stricken with meningitis and became profoundly deaf. Within a few months, the decision was made to proceed with a cochlear implant for Nicole and have her enrolled in a mainstream preschool. In those first two years of preschool, it was determined that the acoustical environment was satisfactory, given that much of the academic instruction was done in small groups or one-on-one. The additional academic support that Nicole received was delivered outside of the classroom in a quiet environment. For the group time, the school purchased a Personal FM Sound Field System that was worn by the teacher and shared with each of the children as they contributed to discussions. This helped Nicole considerably.

> However, when the time came to consider Nicole's kindergarten experience, further discussions began regarding the acoustical environment in the classroom and the impact it would have on her learning capabilities. The cochlear implant, though a miraculous engineering and medical achievement, does not provide hearing capability equal to that of the person with normal hearing. Further accommodations would have to be addressed to help Nicole succeed academically and socially in this mainstream environment. At this time, my daughter asked that I look at the classroom she would be attending and make recommendations for modifications that might improve the overall acoustical characteristics of the room.

The cochlear implant technology has tended to be divisive in the deaf community. Many deaf people argue that the child should learn a sign language (such as American Sign Language) and be acculturated in the deaf community. The following quote helps to explain some of the complexities of this situation (National Association of the Deaf).

> The most basic aspect of the cochlear implant is to help the user perceive sound, i.e., the sensation of sound that is transmitted past the damaged cochlea to the brain. In this strictly sensorineural manner, the implant works: the sensation of sound is delivered to the brain. The stated goal of the implant is for it to function as a tool to enable deaf children to develop language based on spoken communication.
>
> Cochlear implants do not eliminate deafness. An implant is not a "cure" and an implanted individual is still deaf. Cochlear implants may destroy what remaining hearing an individual may have. Therefore, if the deaf or hard of hearing child or adult later prefers to use an external hearing aid, that choice may be removed.
>
> Unlike post-lingually deafened children or adults who have had prior experience with sound comprehension, a pre-lingually deafened child or adult does not have the auditory foundation that makes learning a spoken language easy. The situation for those progressively deafened or suddenly deafened later in life is different. Although the implant's signals to the brain are less refined than those provided by an intact cochlea, an individual who is accustomed to receiving signals about sound can fill in certain gaps from memory. While the implant may work quite well for post-lingually deafened individuals, this result just cannot be generalized to pre-lingually deafened children for whom spoken language development is an arduous process, requiring long-term commitment by parents, educators, and support service providers, with no guarantee that the desired goal will be achieved.

Dyslexia

A significant fraction of people have some level of a neurological disability that has come to be called dyslexia. The definition given here was adopted by the International Dyslexia Association Board of Dyslexia, Nov. 12, 2002 (IDA). This Definition is also used by the National Institute of Child Health and Human Development.

> Dyslexia is a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and / or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.

Sally Shaywitz (2003) has written an excellent and understandable book about dyslexia. Her research suggest that as many as 15 to 20 percent of people have some level of dyslexia. Her book gives the following three steps in the evaluation of a person for dyslexia:

1. Establish a reading problem according to age and education.

2. Gather evidence supporting its "unexpectedness"; high learning capability may be determined solely on the basis of an educational or professional level of attainment.

3. Demonstrate evidence of an isolated phonologic weakness, with other higher-level language functions relatively unaffected.

> Step one is the most critical. Reading tests are easy to understand once you recall that there are two major components of reading: decoding (identifying words) and comprehension (understanding what is read). Accordingly, the assessment focuses on how well the child reads words and on how well she understands what she has read. While accuracy is critical early on, the ability to read fluently gains in importance as the child matures. A child who reads accurately but not fluently is dyslexic.

The ordinary "garden variety" computer is an important assistive device for many dyslexic students. Here is the story of Richard Wanderman, a dyslexic person (Wanderman, n.d.):

> I'm a successful adult with a learning disability (dyslexia). Part of the reason for my success is that I use a variety of tools, including computers, to organize my life and express my ideas. In fact, if I didn't write with

a computer, I wouldn't be able to share this web site with you because I wouldn't be able to record, work with, and share my ideas in writing. And I wouldn't know from personal experience how doing these things with a computer changes the thinking and writing process for people like me.

I had a hard time with school. Most of my memories of school are nightmarish. If I carried the learning disabilities seed (my genetics), then school did a great job of watering and fertilizing it. School made the experience of having a learning disability worse than it would have been otherwise.

Much of my success has come outside of school. I believe strongly in extracurricular, hands-on experience. I've been an artist, a potter, a rock climber, a car mechanic, a teacher, a software developer, and more. All of these experiences have helped me see the difference between my learning disability and my intelligence.

Normal Distribution of IQs

You undoubtedly have some familiarity with the concept of Intelligence Quotient (IQ). Likely you have an intuitive understanding that a person with above average IQ tends to learn faster and better than a person with average or 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 standards deviations above average). Then research suggests (on average) that the IQ 65-70 student will learn at less than one-half the rate of an IQ 100 student, while the IQ 130-135 student will learn at more than twice the rate of the IQ 100 student.

Such statements about learning speed are rather general and "loosey-goosey." However, they suggest that during his or her teaching career, a typical teacher will be faced by a wide range of students, with some students learning perhaps half as fast as the average, and some students learning perhaps twice as fast as the average.

Such observations support a simple-minded and seriously flawed approach to classifying students as Special Education (due to low IQ) or as TAG (due to high IQ) is to use an IQ test along with an arbitrary definition as to what scores constitute being Special Education or TAG. Figure 8.1 shows a Normal curve with the shaded area representing the area between the mean and +1 standard deviations.
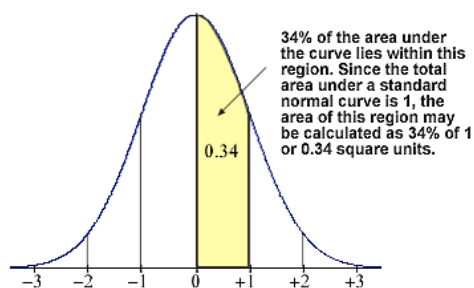
Figure 8.1: Normal distribution curve. Graphic Accessed 12/16/04:
http://www.sasked.gov.sk.ca/curr_content/mathb30/data/les6/notes1.html

Figure 8.2 is a short table of data from a normal distribution. This table indicates that a total of 68.26% of the area under a normal curve lies between –1 and +1 standard deviations. From this table you can deduce that 2.28% of the area lies to the left of –2 standard deviations and 2.28% lies to the right of +2 standards deviations.

Spread	Proportion of Cases
+ or -1 standard deviation	68.26%
+ or – 1.5 standard deviations	86.64%
+ or -2 standard deviations	95.44%
+ or – 2.5 Standard deviation	98.74
+ or -3 standard deviations	99.74%

Table 8.2. Normal curve data

Suppose, for example, that one defines Special Education to mean an IQ less than of equal to –2 standard deviations from the mean. If the particular IQ test you are using has a standard deviation (SD) of 16, then this would mean an IQ of 68 or lower. If the student population being tested has the same distribution characterizes as that used to norm the IQ test, then about 2.28% of the students would be classified as Special Education. Similarly, if one defines TAG to mean an IQ greater than or equal to +2 standard deviations, then this would mean an IQ of 132 or higher, and about 2.28% of students would be classified as TAG.

A different (and still quite arbitrary) cutoff point would be to use –1.5 SD or lower for Special Education and + 1.5 SD or higher for TAG. This would place approximately 6.68% of students into Special Education with a cutoff IQ score of 76, and 6.68% of students into TAG, with a cutoff IQ score124.

These IQ-based definitions of Special Education and TAG are seriously flawed. One obvious flaw is that they give no consideration to what students with a certain IQ (such as an IQ of 65 or an IQ of 135) can do. A more appropriate approach is to use criteria other than IQ to identify students with severe learning disabilities and students who one wants to classify as TAG. Then give a large number of these students IQ tests. From this type of data one can develop ranges of IQ scores and scores on other types of tests that are useful in helping to determine if a student should be classified as severe learning disabled or TAG.

 Another obvious flaw with the IQ approach is that different IQ tests emphasize somewhat different components of IQ. As an example, probably you are familiar with Howard Gardner's work on Multiple Intelligences. Has identified eight different "intelligences" such as linguistic, special, logical/mathematical and musical. From the work of Gardner and others, it is clear that a person might have substantial different intelligence scores in different areas of intelligence. Put another way, if two different IQ tests place different weights (for example, by using different numbers of questions) on various types of IQ, then a person might well score quite differently on the two tests.

Another major flaw is that IQ tests do not measure persistence, drive, intrinsic motivation, and other traits that make a huge difference in learning, problem solving, and other human activities.

Still another major flaw is that IQ is a combination of nature and nature/environment. On average, being raised in an intellectually rich and appropriately challenging home environment leads to having a higher IQ, while being raised in an intellectually poor and inappropriately challenging home environment leads to having a lower IQ.

In brief summary, the fields of Special Education and TAG Education are complex and contain a huge and steadily growing amount of research-based and practitioner-base knowledge. A classification of special education or TAG should not be based on one test, such as an IQ test. A student's parents and classroom teachers can play a major hole in helping to identify students

with special needs. But, all school districts have access to special education and TAG professionals that should be consulted early on.

Children with Special Needs

There are many diagnostic categories of special education children, such as Developmental Disabilities, Neurological Impairments, Learning Disabilities, Physical Disabilities, and so on. ICT is making a significant contribution to helping to identify and meet the needs of children with special needs.

The United States and many other countries have made major commitments (both legally and fiscally) to help meet the needs of special education children. Research funding has made possible considerable progress in this field. This section provides a brief introduction to some of the roles of ICT in helping children with special needs.

Individual Education Program (IEP)

As you know, an Individual Education Program (IEP)—which is also often called an Individual Education Plan—is a central component of work to help a special education student. Quoting from an ERIC Digest article (Smith, 2000):

The Individualized Education Program (IEP) is the cornerstone of the Individuals with Disabilities Education Act (IDEA), which ensures educational opportunity for students with disabilities. The IEP is a quasi-contractual agreement to guide, orchestrate, and document specially designed instruction for each student with a disability based on his or her unique academic, social, and behavioral needs.

…

The IEP can be a dynamic process wherein professionals, parents, and sometimes students, can plan for an instructional future that is truly responsive to the student's unique individual needs. When professionals understand the necessity for the IEP and the opportunity it provides for collaboration, dynamic planning, and successful implementation, the lawful intent of specially designed instruction will be fulfilled. The IEP can be viewed as the product of the referral process and it can be viewed as an educational outline delineating the major part of the service and delivery process.

General discussions such as the one provided above do not provide much insight into possible roles of ICT in an IEP, nor difficulties in implementing appropriate use of ICT. Often the professionals, parents, and students involved in developing an IEP have limited knowledge of current capabilities of ICT as an aid to a student with disabilities.

Computer software has been developed to aid in the creation of IEPs and in maintaining the records and developing the reports that are an important part of creating and implementing an IEP (IEP, n.d.).

CAL and DE

Computer-Assisted Learning, perhaps delivered over the Internet, may be a useful component of an IEP. Reasons for this are rooted in "individualization" and in the Craft and Science of Teaching and Learning. We know the benefits of students having one-on-one and small group tutoring by highly qualified teachers. CAL can achieve some of these benefits.

The Fast ForWord software that was initially developed for use with students who are severely speech delayed because the phoneme processing components of their brains work too slowly provides an excellent example. Quoting from (Fast ForWord, n.d.):

The fruit of this collaborative effort [between Dr. Paula Tallal and Dr. Michael Merzenich] was the development of Fast ForWord Language, a CD-ROM and Internet-based training program designed to

improve phonemic and phonological awareness so to impact language development. Using interactive computer games and acoustically altered speech, the program is a means for training the brain to speed its processing of auditory information. Initially, speech sounds of short duration are stretched artificially, making them more readily distinguishable for a child with temporal auditory processing deficit. As the child becomes more proficient at recognizing the sounds, the Fast ForWord Language program adjusts to the child's improving level of competence by continually shortening the duration of the sound, requiring the brain to process at faster rates of speech. Through a daily repetition of exercises spanning six to eight weeks, brain cells in the auditory cortex are developed and trained to respond. This formation of alternative brain pathways enables the child to recognize previously unheard speech sounds when they are a part of the everyday flow of speech.

The Fast ForWord software provides an excellent example of progress that is occurring in Highly Interactive Intelligent Computer-Assisted Learning. The software provides highly individualized instruction and is rooted in our developing understanding of the human brain. There has been substantial research that supports the effectiveness of this software in helping to meet needs of a wide range of learners (Scientific Learning Corporation, n.d.). Early uses of this software with severely speech delayed students produced results that were far better than what one-on-one help by speech therapists had been able to achieve. The software is now being used with such students, but also for a much broader range of students who are having language and reading problems. The software has also been used effectively with people having cochlear implants.

Assistive Technology

Many students can benefit from assistive technologies, and the Web provides excellent resources on assistive technologies (ABLEDATA). Quoting from ABLEDATA's Website (n.d.):

> ABLEDATA is a federally funded project whose primary mission is to provide information on assistive technology and rehabilitation equipment available from domestic and international sources to consumers, organizations, professionals, and caregivers within the United States.
>
> …
>
> The ABLEDATA database contains information on more than 30,000 assistive technology products (over 20,000 of which are currently available), from white canes to voice output programs. The database contains detailed descriptions of each product including price and company information. The database also contains information on non-commercial prototypes, customized and one-of-a-kind products, and do-it-yourself designs. To select devices most appropriate to your needs, we suggest combining ABLEDATA information with professional advice, product evaluations, and hands-on product trials.

ICT is now a routine component of many assistive technologies. Apple Computer Corporation has a long history of supporting people with special needs that can be met through the use of computers (Apple, n.d.).

In recent years, wireless ICT has reached a level that it is making major contributions to assistive technology.

> Advances in mobile wireless technology are producing portable communication, information, and control devices that connect without wires to local, community, and nationwide networks. These mobile wireless devices support a wide range of applications spanning voice and data communication, remote monitoring, and position finding. Examples of current mobile wireless products include cell phones, pagers, personal digital assistants (PDAs), global positioning systems (GPS) and portable - even wearable - computers. Although there are significant accessibility concerns, mobile wireless devices offer tremendous potential for assisting people with disabilities. This web site serves as an information resource to provide an overview of the mobile wireless technology, applications, and products that are emerging and how these advances can be used to assist rehabilitation, health management, independent living, and quality of life. (Wireless RERC).

Attention Deficit Hyperactive Disorder (ADHD)

Attention Deficit Hyperactive Disorder (ADHD), also known as Attention Deficit Disorder (ADD), affects a large number of students. A child with this disorder cannot maintain attention and has poor impulse control. The child may be restless and overactive. The child tends to attract attention by constantly disturbing others.

Usually people attempt to distinguish the ADHD symptoms and behavior that are genetic from those caused by a pregnant mother's use of drugs and other such causes. Quoting from the Website (ADD ADHD Information Library, n.d.):

> Attention Deficit Hyperactivity Disorder - ADHD - might affect one, two, or several areas of the brain, resulting in several different "styles" or "profiles" of children (and adults) with ADHD.
>
> These different profiles impact performance in these four areas:
>
> • First, problems with Attention.
>
> • Second, problems with a lack of Impulse Control.
>
> • Third, problems with Over-activity or Motor Restlessness,
>
> • Fourth, a problem which is not yet an "official" problem found in the diagnostic manuals, but ought to be: being easily Bored.

This Website provides the estimate that about five-percent of students in the United States are genetically ADHD. It also provides an estimate that another five to ten-percent of the student population may have neurological damage that result in approximately the same symptoms as ADHD. Such neurological damage might, for example, come from exposure to alcohol and other drugs while in the uterus. Note that these statistics suggest that perhaps 10 to 15 percent of children have some level or form of ADHD.

ADHD is a significant problem to a person attempting to adjust to life in our current society, in our schools, in many of our jobs, and in other aspects of our day-to-day life. One might conjecture that these challenges did not exist in the hunter-gather world with its low population 11,000 and more years ago. In this sense, ADHD tends to have become a problem because of our current schooling system and other conditions in our current society.

Earlier in this chapter we briefly discussed dual exceptionalities. The following quoted material discusses dual TAG ADHD students (Webb and Latimer, n.d.).

> Howard's teachers say he just isn't working up to his ability. He doesn't finish his assignments, or just puts down answers without showing his work; his handwriting and spelling are poor. He sits and fidgets in class, talks to others, and often disrupts class by interrupting others. He used to shout out the answers to the teachers' questions (they were usually right), but now he daydreams a lot and seems distracted. Does Howard have Attention Deficit Hyperactivity Disorder (ADHD), is he gifted, or both?
>
> …
>
> While the child who is hyperactive has a very brief attention span in virtually every situation **(usually except for television or computer games)**, children who are gifted can concentrate comfortably for long periods on tasks that interest them, and do not require immediate completion of those tasks or immediate consequences. [Boldface added for emphasis.]

One of the things we know about computers and computer games is that many people find them to be attention grabbing and attention holding. Notice the last paragraph quoted above. It is suggestive of a possible role of ICT in working with ADHD students. The article (ERIC Digest E569, n.d.) specifically recommends "Use of a word processor or computer for schoolwork."

Notice that a previous section of this chapter discusses the value of a word processor for dyslexic students.

Talented and Gifted (TAG)

The TAG designation covers a broad range of students. One might think of TAG on a scale that runs from gifted to profoundly gifted. A student near the left end of this scale may well learn twice as fast as an average student, while a student near the right end of this scale may learn still faster. A profoundly gifted child might graduate from high school and enter college while other students his or her age are entering the sixth grade.

While many TAG students exhibit a high level of talent over a broad range of disciplines, others may exhibit less breadth and greater depth. Quite likely you have heard of some child prodigies who exhibited great depth of talent in one or more narrowly focused areas. Wolfgang Mozart in music and Bobby Fisher in chess serve as good examples (Schaffhausen, n.d.). A prodigy needs an outlet to show his or her talents. This needs to be an outlet in which one can show very high performance without mastering details that take years to master. Thus, a somewhat narrow and self-contained discipline is helpful. Or, multimedia might be considered to fit the bill, as we provide better and better aids to handling needed details of production and editing.

Definitions of Giftedness

Former U. S. Commissioner of Education Sidney P. Marland, Jr., in his August 1971 report to Congress, stated (Marland, 1971):

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.

…

Using a broad definition of giftedness, a school system could expect to identify 10% to 15% or more of its student population as gifted and talented. A brief description of each area of giftedness or talent as defined by the Office of Gifted and Talented will help you understand this definition.

General intellectual ability or talent. Laypersons and educators alike usually define this in terms of a high intelligence test score--usually two standard deviations above the mean--on individual or group measures. Parents and teachers often recognize students with general intellectual talent by their wide-ranging fund of general information and high levels of vocabulary, memory, abstract word knowledge, and abstract reasoning.

Specific academic aptitude or talent. Students with specific academic aptitudes are identified by their outstanding performance on an achievement or aptitude test in one area such as mathematics or language arts. The organizers of talent searches sponsored by a number of universities and colleges identify students with specific academic aptitude who score at the 97th percentile or higher on standard achievement tests and then give these students the Scholastic Aptitude Test (SAT). Remarkably large numbers of students score at these high levels.

Creative and productive thinking. This is the ability to produce new ideas by bringing together elements usually thought of as independent or dissimilar and the aptitude for developing new meanings that have social value. Characteristics of creative and productive students include openness to experience, setting personal standards for evaluation, ability to play with ideas, willingness to take risks, preference for complexity, tolerance for ambiguity, positive self-image, and the ability to become submerged in a task. Creative and productive students are identified through the use of tests such as the Torrance Test of Creative Thinking or through demonstrated creative performance.

Leadership ability. Leadership can be defined as the ability to direct individuals or groups to a common decision or action. Students who demonstrate giftedness in leadership ability use group skills and negotiate in difficult situations. Many teachers recognize leadership through a student's keen interest and skill in problem solving. Leadership characteristics include self-confidence, responsibility, cooperation, a tendency to dominate, and the ability to adapt readily to new situations. These students can be identified through instruments such as the Fundamental Interpersonal Relations Orientation Behavior (FIRO-B).

Visual and performing arts. Gifted students with talent in the arts demonstrate special talents in visual art, music, dance, drama, or other related studies. These students can be identified by using task descriptions such as the Creative Products Scales, which were developed for the Detroit Public Schools by Patrick Byrons and Beverly Ness Parke of Wayne State University.

Psychomotor ability. This involves kinesthetic motor abilities such as practical, spatial, mechanical, and physical skills. It is seldom used as a criterion in gifted programs.

There are a variety of definitions and measures for gifted, highly gifted, and profoundly gifted students. The following quote from the ERIC Clearinghouse on Disabilities and Gifted Education defines these three categories in terms of scores on the Weschler Intelligence Scale for Children (ERIC, Profoundly Gifted).

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.

Federal and State Support for TAG Students

Unlike children with disabilities, Talented and Gifted children receive relatively little protection under U.S. Federal Law. Without a federal law to protect the legal rights of gifted children, the responsibility for such mandates rests with the states. More than 30 states have a mandate to serve gifted children, while the remaining ones have permissive legislation (Council of State Directors of Programs for the Gifted, n.d.). The nature and extent of TAG services funded at a state level vary widely from state to state. In Oregon, for example, the funding level is approximately $2.50 per student per year. The state mandates that TAG students be served, but the fiscal burden falls entirely on the local schools and school districts. Needless to say, this leads to tremendous variations within the state as to how well these students are served.

The Federal Government does support one major TAG program, the Jacob K. Javits Gifted and Talented Students Education Program (Javits, n.d.).

In FY 2002, under the reauthorization of the ESEA (the No Child Left Behind Act), absolute priorities were established to encourage activities that contribute to an understanding of the most effective ways to educate gifted and talented students who are economically disadvantaged, limited English proficient, or who have disabilities. This shift in focus builds upon the outcomes of nearly 125 demonstration programs and practices for educating talented students nationwide since the inception of the Javits program in 1989. Absolute Priorities: Grants are awarded under two priorities. Priority One supports initiatives to develop and "scale-up" models serving students who are under-represented in gifted and talented programs. Priority Two supports state and local efforts to improve services for gifted and talented students.

…

The Javits program funds the National Research Center on the Gifted and Talented located at the University of Connecticut at Storrs, in collaboration with the University of Virginia, Yale University, and Columbia University. The consortium includes over 360 public and private schools, 337 school districts, 52 State and territorial departments of education, and a consultant bank of 167 researchers associated with 86 universities throughout the United States and Canada.

Some General TAG Considerations

TAG education existed well before the development of ICT. As computers became available, a variety of people explored uses of them in TAG education. In the early days of computers, it was often thought that if a TAG student was given access to a computer, then automatically and with little or no instruction, great things would happen. However, this is the exception, rather than the rule. It is true that Steve Jobs who helped found Apple Corporation and Bill Gates who founded Microsoft Corporation "made it" without the benefit of a lot of ICT help from their teachers. Indeed, a number of other examples can be found of TAG children who have had a high level of success in various aspects of ICT in business.

However, such success stories are few and far between when measured against the TAG population. Suppose, for example, one uses a somewhat stringent measure of giftedness, and that only five-percent of students meet this definition and are classified as TAG. This amounts to more than 200,000 students at each grade level in U.S schools.

Think about these students from the point of view of David Perkins' list of goals of education. (Figure 8.1 is the same figure we discussed in Chapter 0.)

1. Acquisition and retention of knowledge and skills.

2. Understanding of one's acquired knowledge and skills.

3. Active use of one's acquired knowledge and skills. (Transfer of learning. Ability to apply one's learning to new settings. Ability to analyze and solve novel problems.)

Perkins' Three Goals of Education

Lower-order   Higher-order

Acquisition and Retention   Understanding   Use to Solve Problems & Accomplish Tasks
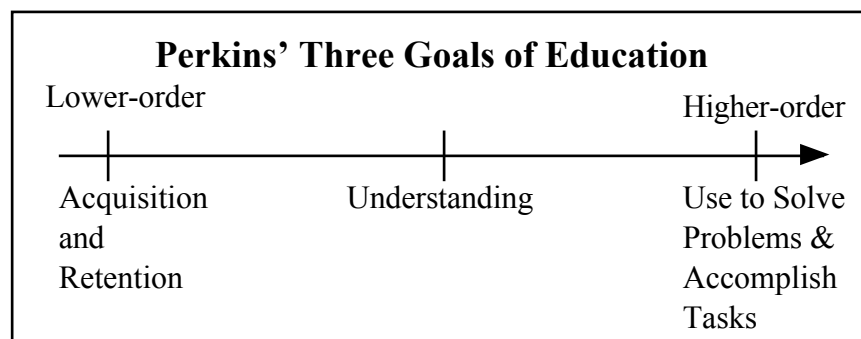
Figure 8.1. Scale: lower-order to higher-order goals of education.

As a teacher, what do want to help your TAG students to accomplish? You could focus on such students memorizing a much larger amount of data and information, and then practicing enough to facilitate long-term retention of what has been memorized.

You could focus on your TAG students gaining a broader and deeper understanding of the curriculum that you are teaching.

And, you could create an environment and set of requirements that pushed your TAG students toward the higher end of the scale, toward working on complex problems and tasks. This is one of the places in which ICT can make a major difference. Some problems and tasks take a very broad and mature level of knowledge (and wisdom) to address. Others are more narrowly focused.

Let's take music composition for an example. Music is somewhat narrowly focused, which has allowed it to produce prodigies such as Mozart. However, think about the difficulties faced

by a person who is going to develop musical composition knowledge and skills at a young age. One difficulty is having some way to perform one's compositions, or to have them performed. Another difficulty is having some way to represent (for example, in musical notation) one's compositions. Both of these difficulties are now being well addressed by music-specific ICT tools. With such tools, even average elementary school students can compose music and have it be performed by a computer system.

Next, lets consider the study of history. Causality is of the most important ideas in the study of history. This involves the generation and testing of hypotheses, somewhat akin to what one does in science and in other fields of inquiry. The traditional textbooks we make available to students studying history are severely limited in their usefulness in generating and testing hypotheses, or in exploring other aspects of causality. Contrast such resources with the rapidly growing collection of primary resources available on the Web. Keep in mind that history is part of every discipline. Thus, the Web opens up the "deep" study of history by students at every grade level and in every discipline.

Next, consider the field of hypermedia. We have long had sound recording equipment along with still and motion cameras. However, the equipment for editing photographs, video, and audio has been both expensive and difficult to learn to use. Now, ICT has made such facilities relatively inexpensive and easy to learn to use. Moreover, such equipment facilitates the development of animation and of interactivity. These capabilities open up an entire new range of opportunities for a person who is interested in communication using hypermedia.

Finally, consider the discipline of computer programming. With proper instruction, even primary school students can learn to program in Logo or BASIC. For such students, this opens up a new world of problems to be solved and tasks to be accomplished. In some sense, this world is self-contained, which means it facilitates the development of prodigies. However, this world overlaps with the problems and tasks in every academic discipline. Thus, computer programming is open ended both as an area of study in its own right and as a tool in other academic disciplines.

The examples share four things in common:

1. ICT is a powerful aid to representing and helping to solve the problems. However, creativity, deep and careful thinking, and persistence are all essential.

2. Role models of good (high level) performance are available to students.

3. Guidance and instruction from well-qualified people (teachers and other professionals) is of great help.

4. They are all open ended. There are no upper limits to what a student might learn and achieve.

An Appropriately Challenging Curriculum

Many TAG students are not adequately challenged by the traditional curriculum and its accompanying assessments. Computer-Assisted Learning and Distance Learning open up many possibilities for challenging the abilities of TAG students. Such courses can be used to broaden the breadth and/or the depth of a TAG student's education.

Earlier in our discussion of TAG students we have mentioned that such students learn faster and better than average students. You realize, of course, that some students learn faster and better than other students, even if they are not classified as TAG. To help you understand the cumulative effect of a greater rate of learning, consider a student who learns just 50 percent

faster and better than the average of his or her fellow students. Such a student might well not even meet the local school standards for being classified as TAG. But, such a student might well be capable of completing the 13 years of K-12 education and taking a rigorous curriculum of study in 9 to 10 years.

Two common approaches to working with TAG students are   and acceleration. Enrichment tends to focus on inclusion of the child in the regular classroom and grade level of his or her age peers. Acceleration tends to focus on moving the child ahead in one or more discipline areas or in grade levels. Our current secondary school system provides a combination of enrichment and acceleration through its "college prep" curriculum that may include a number of advanced placement courses. Students can stay in school with their age group but may be able to earn as much as a year of college credits during high school. The increasing availability of Distance Learning advanced placement courses helps to make such options available to students in schools that do not offer such courses. In addition, we are now seeing increasing emphasis on making college courses available to such students from a nearby community college, college, or university.

There is quite a lot of literature on "inclusion" of TAG students in the regular classroom curriculum. *Meeting the Needs of Gifted Students: Differentiating Mathematics and Science Instruction* is a good example (NWREL, 1999). Quoting from the Preface of this book:

> Meeting the Needs of Gifted Students: Differentiating Mathematics and Science Instruction offers teachers a variety of strategies and resources for providing different levels of content and activities that will challenge all students, including gifted learners. A consistent theme throughout this publication is that while many of the ideas come from the body of literature and research on gifted education, the strategies are appropriate and effective for a wide range of students. Another important theme emerging from the research base on gifted students is the need to re-examine the criteria and processes used to designate some students as gifted, and thus by implication all other students as not gifted. Clearly, relying on a narrow definition such as those who score in the top 10 percent on a standardized achievement test can exclude students with special talents who may have difficulty in taking tests.

Assessment for TAG Students

Appropriate assessment of TAG students is a significant challenge. One of the important characteristics of TAG is the ability to perform (solve problems, accomplish tasks) well above the level of one's peers. Thus, alternative, authentic assessment is often suggested as being especially appropriate for TAG students. The following is quoted from the Website (McAlpine):

> Likewise, the concept of giftedness has broadened to include a wide range of abilities including the creative, social, visual and performing arts, etc. Assessments related to these wider dimensions have also been developed, although seldom with the degree of reliability associated with tests of "intelligence" or scholastic abilities.
>
> …
>
> Norm-referenced tests allow students with special abilities to excel, to be "tops". However, criterion referenced assessments do not offer such opportunities. Assessment tasks related to this form of assessment often have low "ceilings" (little challenge) and progress in small step-by-step increments and sequences. In a recent study, gifted students reported that assessments based on unit standards in school trials in maths and geography (secondary schools) lacked challenge and were "boring" (Coutts & McAlpine, 1996). A wide range of assessment procedures is available to teachers today. Some of these procedures are relevant and promising for students with special abilities and many teachers in New Zealand are utilising them well with this and other groups of students. I have selected three forms of assessments, which are particularly relevant for students with special abilities, for brief discussion over three issues of *Tall Poppies*. These are:
>
> • portfolio assessment

• authentic assessment

• self assessment.

Final Remarks

This chapter explores some aspects of special and TAG education. As a teacher, you need to keep in mind that individual differences are the norm. That is, each of your students is unique. Our educational system identifies some students as "special education" and some students as TAG. Some students fall into both classification categories.

Our educational system has moved strongly in the direction of inclusion of special education and TAG students into the regular classroom. This presents a major challenge to teachers, especially teachers who have had little training and experience in working with special education and TAG students.

As noted throughout this book, ICT is a significant aid to both students and teachers, and it is a significant challenge to both students and teachers. In some aspects of special education and TAG education these challenges are amplified, and in some cases the rewards or successes are amplified. ICT is but one component of the set of knowledge, skills, and tools available to a teacher. Sometimes, however, ICT has the power to be especially powerful in helping to meet the needs of a student.

Activities for Chapter 8

1. Do a careful introspection on your mental and physical strengths and weaknesses. Look for examples of "exceptionalities" that you are aware of and have accommodated to.

2. Select a state and explore its rules, regulations, and funding for TAG. The Web is an excellent resource for conducting such a study.

3. Steven Hawking is an excellent example of a highly gifted person whose has severe disabilities. ICT adaptive technologies have made major contributions to his work and quality of life. Explore what he has done during his career and look for other examples of highly successful individuals with Dual Exceptionalities who are making substantial use of ICT adaptive technologies.

4. Spend some time talking to some special education and TAG students. Explore their understanding of their exceptionalities, and explore their use of ICT. Pay special attention to when and how they became aware of their exceptionalities. Do they feel that learning about their exceptionalities has been advantageous, or not?

Chapter 9

Summary and Recommendations

"When you're finished changing, you're finished." (Benjamin Franklin)

"I never see what has been done; I only see what remains to be done." (Marie Curie)

"Never doubt that a small group of thoughtful committed citizens can change the world: indeed; it's the only thing that ever has." (Margaret Mead)

This is the final chapter in the current form of this book. It begins with a brief summary of the underlying conceptual idea of the book. It then provides a set of recommendations for readers.

Future versions of the book may contain one or more additional chapters. But, don't hold your breath while waiting for additions. Instead, please make use of the materials given at http://darkwing.uoregon.edu/~moursund/dave/Free.html. Many of these free materials were specifically designed for use in ICT courses and workshops for preservice and inservice teachers.

ICT in Education from a Problem-Solving Point of View

ICT provides a wide range of aids to solving problems and accomplishing tasks. ICT is now a significant component of the basic content of each of the disciplines that students study at the precollege level. In addition, ICT provides generic "productivity tools" that cut across all of the disciplines that students study.

ICT is a dynamic field, growing rapidly in breadth and depth. Basic hardware capabilities of ICT, such as computer speed, computer storage capacity, telecommunications bandwidth, and the installed base are all growing rapidly. The next 15-20 years will likely bring us increases in computer speed, memory capacity, and telecommunications bandwidth by a factor of 1,000 or more. These hardware improvements, along with continued progress in software, will have a profound impact on the societies of our world.

This book began by emphasizing that the ideas in the diagram in Figure 9.1 serve to unify this book. Suppose someone asks you: "What is the most important idea in educational use of ICT?" I believe that you should respond: "ICT as an aid to solving problems and accomplishing tasks." You can then go on to explain that solving problems and accomplishing tasks can be viewed from a teacher point of view and from a student point of view. In both points of view, ICT contributes substantially to accomplishing the core goals of education (Perkins, 1992, p5):

1. Acquisition and retention of knowledge and skills.

2. Understanding of one's acquired knowledge and skills.

3. Active use of one's acquired knowledge and skills. (Transfer of learning. Ability to apply one's learning to new settings. Ability to analyze and solve novel problems.)

The next two sub-sections briefly discuss the teacher and the student points of view.
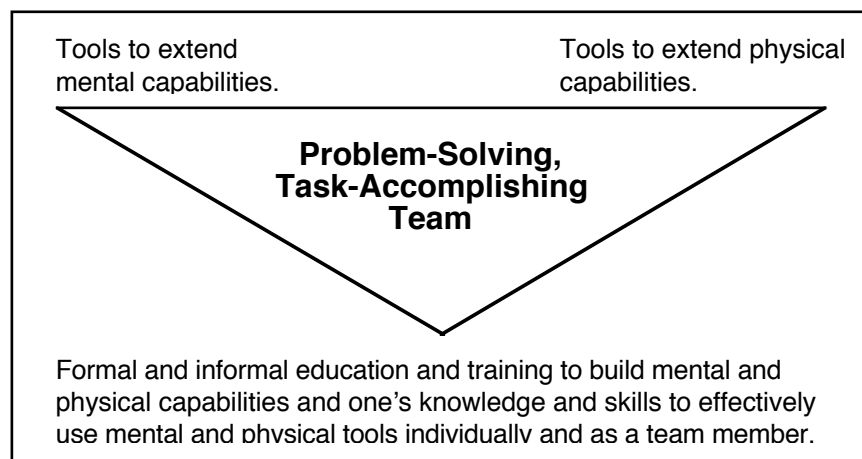
Figure 9.1. Aids to problem solving.

Teacher Point of View

A teacher has many responsibilities. Sometimes these are grouped into four major categories:

- Curriculum
- Instruction (pedagogy)
- Assessment
- Personal professional growth

By now you should understand some important roles of ICT in each of these four areas. For example, you should understand the concept of "ICTing" across the curriculum and in the content areas in the same way that you understand writing across the curriculum and in the content areas, or reading across the curriculum and in the content areas.

In addition, you should understand that ICT is now part of the core content in each of the disciplines you are teaching or planning to teach. The importance of ICT as core content varies with the discipline, but is increasing in all disciplines.

As a second example, consider pedagogy. Of course you understand roles of ICT in interacting with a class, such as via use of a desktop presentation system. You understand the some of the value of having your handout materials and tests in electronic form, and perhaps the value of having a Website to support your teaching activities. You know that Computer-Assisted Learning is slowly but steadily improving. You understand that there are now important content areas in which Highly Interactive Intelligent Computer-Assisted Learning is more effective than a teacher working with a classroom full of students.

In the area of assessment, you know that at state and national levels there is growing use of Computer Adaptive Testing. This is gradually filtering down to the individual school district and school level. The trend is clear. Computer Adaptive Testing over core content areas such as Language Arts, Mathematics, Science, and Social Studies will gradually become commonplace at the individual school level. CAT will gradually move toward providing detailed feedback to teachers on the strengths and weaknesses of individual students.

Also in assessment, you face the growing task of authentic "hands-on ICT facilities" assessment. As students become more comfortable in the routine use of ICT, and as the available

of ICT facilities at home and school continue to grow, schools need to appropriately address the issue of hands-on ICT assessment. As an example, suppose that a child has spent years developing skill at using a word processor to write. Then it seems reasonable that tests that involve wiring will allow the student to use a word processor and the writing aids it provides.

Finally, consider your professional career and the challenges of "keeping up" and continued professional growth. ICT is both and aid and a problem in these endeavors. Remember, you can look forward to improvements in ICT hardware by a factor of 1,000 or more during the next 15 to 20 years.

Student Point of View

A student's point of view of education tends to be quite a bit different than the point of view of a teacher's and other adults. As teachers, we often talk about student-centered learning or a student-centered curriculum, instruction, and assessment. But, to a very large extent, curriculum content is not determined by students. Instead, it is determined by textbook writers and publishers, teachers, district and state curriculum committees, and so on. For the most pare, instructional processes are determined by teachers, and assessment is determined at a combination of the teacher level and levels above the teacher.

The people who determine curriculum, instruction, and assessment have in mind the types of educational goals stated by David Perkins, and they also have in mind some other goals. For example, we want each student to good and continuing progress toward achieving his or her "full potentials." We want each student to make appropriate progress toward being an independent, self-sufficient, intrinsically motivated, lifelong learner. We want each student to become a responsible adult citizen. A good teacher is good at engaging students in these endeavors.

Think, for a minute, how our educational system might give more power to students. What might student-centered education look like from a student point of view? How can ICT aid in making our educational system more student centered?

Answers to this question are both simple and complex. From the very beginning of formal education we (educators) can increase our focus on student question asking, problem solving, task accomplishing, learning to learn, self-assessment, and other higher-order cognitive skills. We can provide students with grade-appropriate understanding of the idea that they bear a major responsibility in their own learning and cognitive growth. We can help students to see their growth as learners, and we can provide multiple opportunities and methods for growth and displaying the growth.

Here is a simple-minded example to accompany the above ideas. Wouldn't it be interesting if each day each student posed one or more questions relevant to his or her learning interests, and then used the Web to research answers? Perhaps you can think of ways to integrate this idea into your current or future teaching. And, you might begin by integrating it into your current learning habits if this is not already one of your habits.

Who Has the Power?

One can analyze our educational system from the viewpoint of who has the power, or who is appropriately empowered in the areas most important to the various participants. For example, Seymour Sarason has analyzed education from the point of view of how well teachers are empowered (Sarason, 1993). He argues that the best way to improve our educational system is to increase the power of teachers.

One can also analyze our educational system from the point of view of the power of students. ICT is shifting power from teachers to students. Student access to the Web provides a good example of how this is occurring. A student can easily gain knowledge that his or her teacher does not have. Thus, the teacher can no longer be considered "the fount of all knowledge."

Computer-Assisted Learning and Distance Learning are also empowering students. The teacher and the curriculum offered by a school must now compete with other sources of instruction and academic credit.

ICT, in and of itself, tends to favor students over teachers. Students grow up with the technology (thus, they are not faced by ICT as a change), while many teachers tend to struggle to adjust to the pace of change of ICT.

Recommendations to Educators

Figure 9.2 is the same as Figure 0.5. In some sense it summarizes ICT-related problems faced by our educational system.

Areas in which ordinary people can readily outperform ordinary ICT systems.

Areas in which ordinary ICT systems can readily outperform ordinary people.

Areas in which people versus ICT system performance is currently undecided and/or where the two together readily outperform either alone.
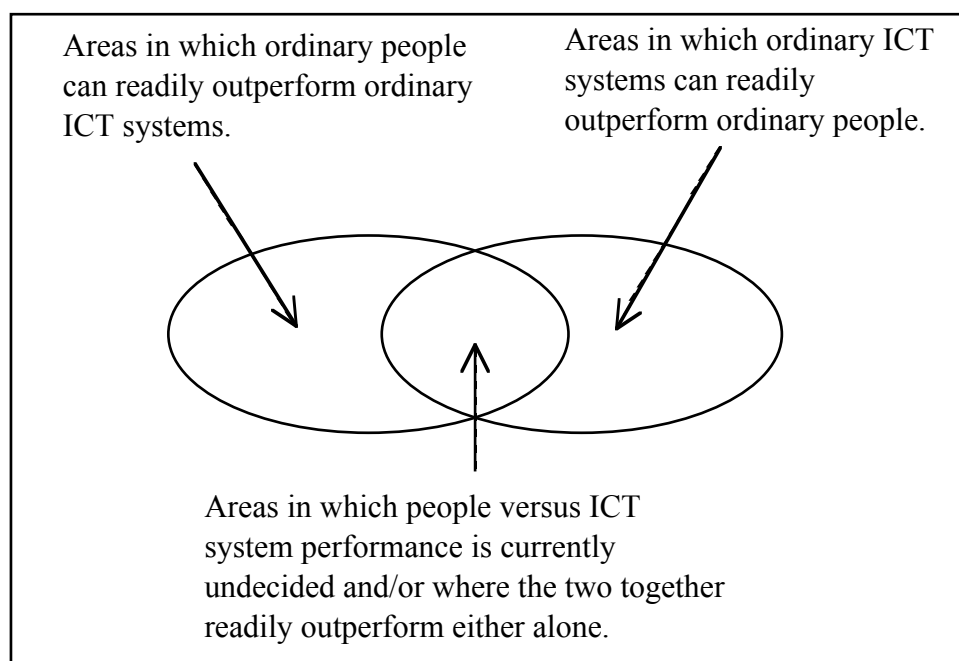
Figure 9.2. Roles of people and ICT systems in solving problems and accomplishing tasks.

The issues raised in this book and illustrated in Figure 9.2 face all teachers. A major goal in preservice and inservice teacher education is to help prepare teachers to effectively deal with these challenges. Here is a set of recommendation:

Recommendation # 1: In each academic discipline currently being taught in our schools, ICT has become a useful aid to representing and helping to solve problems and accomplish tasks. Thus, the diagram of Figure 9.2 is applicable to every teacher and student. This means that you need to learn about the capabilities and limitations of ICT within the disciplines that you teach or plan to teach. The curriculum, instruction, and assessment in your everyday classroom needs to adequately and appropriately reflect your best insights into achieving an appropriate balance among the three components of the diagram.

An earlier part of this chapter discusses lower-order and higher-order knowledge and skills. We know that a path to increasing expertise in a discipline includes both lower-order and higher-order knowledge and skills. A teacher faces the challenge of helping to chart a path that is appropriate to the current knowledge, skills, interests, intrinsic and extrinsic motivation, and so on of each individual student. Meeting this challenge requires both a concerted effort on the part of the teacher and the understanding cooperation of the individual student. Here is a recommendation:

> **Recommendation # 2:** You should adopt the goal of helping each student gain increased expertise in being an independent, self-sufficient learner. Each learner should understand (make personal use of) constructivism, metacognition, lower-order and higher-order knowledge and skills, transfer of learning, self-assessment, and gaining increased expertise within a discipline. ICT is quite useful in creating environments in which a student can practice these ideas.

One of the major goals of education is for a student to gain steadily increasing expertise in the very broad area of solving problems and accomplishing tasks. This includes posing problems and tasks, question asking, higher-order "critical" thinking, and making wise decisions. Problem solving is part of each discipline. Keep in mind that expertise in problem solving is built on a combination of discipline-specific (domain-specific) knowledge and skills, and broad-based knowledge and skills that cut across many disciplines. Our educational system can become much better at helping students transferring their discipline-specific problem solving expertise to other disciplines. Here is a recommendation:

> **Recommendation #3:** You should adopt the goal of helping each student understand the ideas represented in Figures 0.1 to 0.5 in Chapter 0 at a level appropriate to the students cognitive development. These diagrams and the ideas that they summarize should be periodically revisited as a student moves from grade to grade, and as a student delves more deeply into various disciplines made available in secondary school. Your students need to understand what it means to gain increasing expertise in a discipline, as well as current and potential roles of ICT that are useful in achieving and performing at an increasing level of expertise.

> In each discipline that you teach, help you students to understand what constitutes an increasing level of expertise within the discipline and how the instruction you are currently providing contributes to this increasing expertise. Weave this effort into an effort to increase transfer of learning of problem solving expertise into other disciplines.

Teaching is a difficult and challenging profession. You may have heard the expression "She is a 'born' teacher." This can be interpreted as a comment about the nature versus nurture issue of becoming a good teacher. Good teaching requires a very broad range of knowledge and skills. Good teachers vary tremendously in their mental, physical, emotional, social, and other areas of innate abilities. A teacher's expertise is based on his or her developed abilities to effectively use his or her innate abilities that are relevant to being a teacher. Moving up a "good teacher" expertise scale is no different than moving up any other expertise scale. Every preservice and inservice teacher can become a better teacher. Here is a recommendation:

> **Recommendation # 4:** As a teacher, you have a substantial level of expertise in helping students learn, learn to learn, and to gain increased expertise in a variety of disciplines. **Apply this expertise to your own development**. Examine your relative strengths and weaknesses (your capacity) on a "good teacher" expertise scale. Develop ways to self-assess progress you are making toward becoming a better teacher.

ICT provides you with an area to practice gaining increased expertise as a teacher. If you consider your overall knowledge and skills as they relate to being a good teacher, you may find that you have not yet achieved a good balance between those that are ICT-related and those that are not ICT-related. Look for an example where the imbalance seems particularly strong. Devise and implement a plan to help address this imbalance.

You have some knowledge and skill in using a variety of widely applicable ICT tools, such as a word processor, email, and the Web. There are many other generic (general purpose, applicable across many disciplines) ICT tools such as a spreadsheet, a database, and draw and paint graphics. The International Society for Technology in Education, as well as many states and school districts, have set standards (goals) for student knowledge and skills in using these tools (ISTE NETS, n.d.).

You need to give careful thought to the idea that a learning goal might be to learn a specific tool versus the idea that a learning goal might be to learn to effectively use a particular tool as part of gaining expertise within a discipline. As an example, great skill in using a word processor (i.e., fast and accurate keyboarding, skillful use of a spelling checker) does not, in and of itself, make a student into a better writer. The goal is for a student to learn to make effective use of a word processor as part of moving up the expertise scale in effective written communication. Here is a recommendation:

Recommendation # 5: ICT provides a large number of general-purpose (generic) tools, as well as a still larger number of tools that are quite specific to particular domains. Each tool is designed as aid to representing and solving the problems, and representing and accomplishing the tasks, within one or more domains. From a general education point of view, increased expertise in using a tool should focus on its use as part of increasing problem-solving, task-accomplishing, and other higher-order aspects of expertise within a domain.

As a simple example, consider a four-function calculator. Some people learn touch keyboarding of a four-function calculator. This is highly useful in a job that requires great speed and accuracy at entering numbers and doing simple arithmetic operations on them. But, that skill is a very modest part of learning to understand, represent, and solve arithmetic problems. It takes only a modest amount of time for a student to learn to make effective use of a calculator. It takes years of instruction and practice for a student to meet contemporary standards of expertise in the field of math that we call arithmetic.

Final Remarks

Here is a quote from Omar Khayyam, a mathematician (and, also successful in other fields). http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Khayyam.html. Born: 18 May 1048 in Nishapur, Persia (now Iran) Died: 4 Dec 1131 in Nishapur, Persia (now Iran).

"The Moving Finger writes, and, having writ,

Moves on: nor all thy Piety nor Wit

Shall lure it back to cancel half a Line,

Nor all thy Tears wash out a Word of it."

Writing and publishing have changed quite a bit since Omar Khayyam's time. With the assistance of my trusty word processor and Website composition software, I make frequent changes in what I have written and published. Thus, a more modern statement:

The moving fingers keyboard, and, having keyboarded

Move on; however, all thy Piety and Wit

Often lure them back to cancel half a Line or more,

And thy tears can lead to washing out sentences and paragraphs.

Activities for Chapter 9

1. You have had many years of formal education. Analyze the success of this education in developing your expertise to be an independent, self-sufficient, intrinsically motivated, lifelong learner. What might have occurred in the past or what might occur in the future to move you up this expertise scale?

2. What are your personal thoughts about student-centered instruction and empowering students?

3. Analyze the five recommendations given near the end of this chapter. Which one do you most agree with, and which one do you least agree with. Why?

4. Based on your understanding of ICT and education, add a sixth recommendation to the list of recommendations given near the end of this chapter.

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"The valid test of a student is his ability to ask the right questions. I would suggest that we evolve a new type of examination paper, one in which the answers are given -- the questions to be supplied by the student." (Abraham Heschel, 1960)

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

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