Chapter Thirteen

Reflections on Education for an Information Age

> What avail is it to win prescribed amounts of information about geography and history, to win ability to read and write, if in the process the individual loses his own soul...if he loses his desire to apply what he has learned and, above all, loses the ability to extract meaning from his future experiences as they occur.
>
> *John Dewey (1859-1952)*

> A teacher is a person with a touch of immortality, and he should be most envied among men. His profession should be the most sought after, the most carefully prepared for, the most universally recognized.
>
> *Samuel Gould*

> The mind, stretched by a new idea, never goes back to its original dimension.
>
> *Oliver Wendell Holmes (1809-1894)*

LEARNING OUTCOMES

Chapter 1 of this book presented some of the conclusions drawn from the research into the effectiveness of computer-based teaching and learning. Many of those conclusions, while tentative, are sufficiently impressive to justify the introduction and use of computers in classrooms where they have been thoughtfully integrated into the learning process.

Computer-integrated education works best when it is well-planned, well-integrated, closely monitored as to its effectiveness like any other methodology, and given a fair chance. "A fair chance" can only be guaranteed if computer-based teaching and learning is constructed on the seven pillars of success. We will discuss these pillars of success in the conclusion to this final chapter of the book.

The major educational theories and methodologies have timeless merit and are still applied in classrooms today. After all, as Confucius said: "The nature of people is always the same; it is their habits which separate them" (Fersh, 1982). It will be interesting to see what pedagogical "habits," if any, need to be changed when computers are factored into the learning equation.

How might traditional theories of learning be best applied? What are some of the mistakes made by teachers when using computer technology? What help is available for teachers who are new to using computers in the classroom? What is the future for schools if the integration of technology-based education continues at the present pace?

These are some of the questions addressed in this chapter, which will cover the following topics:

- Computers, learning theory, and cognitive development
  - Computers and learning
  - Learning theory

- The Importance of Individualized Education
- Caveats regarding computer use in the Classroom
- Computer-Integrated Teaching and Learning: The Ten Pillars of Success
- Taking Care of the Teachers
  - Teachers must have time
  - Teachers must have ongoing training
  - Teachers must have logistical and technical support
- A Final Word from John Dewey

COMPUTERS, LEARNING THEORY, AND COGNITIVE DEVELOPMENT

Computers and Learning

The computer is a general purpose machine. Indeed, as you may recall, Alan Turing (1937) demonstrated that it is in theory a "Universal Machine." You may recall from Chapter 2 that John Vincent Atanasoff, the inventor of the electronic digital computer, had educational goals in mind when he invented his machine. With the application of human intelligence, the computer is becoming a useful tool for a diverse set of learning tasks, from reading and writing, to doing math, monitoring attendance, simulating scientific experiments and social conditions, enabling handicapped children to join the mainstream of education on equal terms, to name but a few.

Educators have been quick to imagine ways in which the computer can be programmed to foster the learning process. This was true as early as the 1960s, when computers were mighty, multi-million dollar behemoths owned only by governments and major corporations. A few enterprising teachers were linking up with these corporations and shepherding students across town to give them the opportunity to develop problem-solving skills by writing programs.

Bill Gates and Paul Allen (Fig. 13.1), co-founders of Microsoft Corporation, first learned to program as teenagers in the 1970s on a DEC PDP-10 at the University of Washington[1].

Fig. 13.1 Bill Gates (standing) and Paul Allen in the early days

[1] Computer-Schools,us, 2003

From day one, computers have been important research tools, especially for scientists and engineers. By the late 1960s these latter were joined by researchers in all fields of learning when database management systems (DBMS) enabled the easy storage and retrieval of huge amounts of text-based data (Date, 1986). The descendants of these DBMS are the engines driving multimedia and distance learning computer systems today.

So computer use in schools is not new. The question is: Is its use founded on sound pedagogical principles? Before we answer that question, it will be useful to review the various ideas about learning and cognitive development that guide teachers when they formulate methodologies for helping students in their acquisition of knowledge. After all, decisions about how and when to use computers to improve the quality of a child's education must be predicated on the knowledge and experience of the teachers responsible for preparing and maintaining the environment in which that education takes place.

Learning Theory

How children *learn* has been the topic of much debate and is naturally an important subject of study for teachers. There is no one best approach to enabling learning that can be applied in all situations with all students (Bigge, 1982). For this reason, student teachers who are well-prepared for the classroom are expected to study, experience, and apply (at least in a laboratory setting such as in-course simulations, or during field experiences and student teaching) a range of learning theories. Study of the theory of education is designed to help teachers become familiar with a body of research in order to inform their application of teaching methodologies so that students have the best possible learning experience.

Cognitive Development There is a significant body of research that helps us to assess our students' academic standing in relation to cognitive developmental based on variables related to their age and intellectual maturity.

Jean Piaget (Fig. 13.2) philosophized that children construct their own sense of the world based on their experience.

Fig. 13.2 Jean Piaget (1896-1980)

Specifically, Piaget (1954, 1971) observed that all children follow a progression towards intellectual maturity, from the initial sensori-motor stage (birth to 18 months/2 years) to the symbolic or pre-concrete operational stage (18 months to 7/8 years) to the concrete operations stage (7 years to 12 years) and finally to the stage where the child becomes capable of formal operations (12 to 15 years).

Jerome Bruner (Fig. 13.2), who studied with Piaget in Switzerland, acknowledged Piaget's work when he refined the stages of human cognitive growth, noting the progression in the ways children "represent their experience of the world."

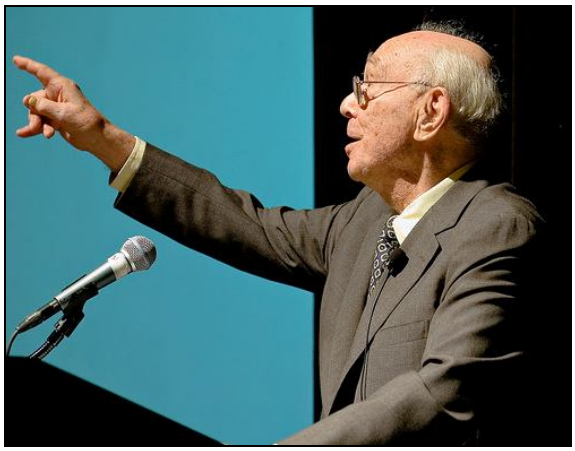

Fig. 13.3 Jerome Bruner (1915-)

This progression goes from the *enactive* mode (where actions are the byway to understanding), to the *ikonic* mode (where images are used to represent experience), and finally to the *symbolic* mode (where language in its many forms enables cognitive understanding and expression of reality). These three modalities of learning, while sequentially acquired by young children as they grow, are also applied by adult learners as they continue to learn throughout their lives.

Lev Vygotsky (Fig. 13.4) sees the learner as willingly active in the pursuit of an individualized understanding of experience.

Fig. 13.4 Lev Vygotsky (1896-1934)

Driven by curiosity about a world which in real terms expands with this experience, the learner seeks answers to questions as they arise: What is this? Where is this? What will happen if I do this? Who is this? and so on.

Finding answers to this constant stream of curiosity-driven questions involves the learner in equally constant, though not necessarily productive (i.e. effective, or correct), construction of mental and physical solutions. As Perkins (1991) observes: "Central to the vision of constructivism is the notion of the organism as "active"—not just responding to stimuli, as in the behaviorist rubric, but engaging, grappling, and seeking to make sense of things."

A key component of Vygotsky's philosophy of learning is the Zone of Proximal Development—a zone around the child in which other agents (family, friends, neighbors, culture) and environmental artifacts (toys, animals, local geography, climate, to name but a few), inevitably impinge upon the knowledge base constructed by a child. Teachers, too, along with a student's peers, are in the "zone of proximal development," where guidance and collaboration augment the child's natural and independent development. It is the rare child, after all, who can "discover" unaided the skills required to contribute effectively in today's information-intensive world.

Perkins (1991) echoes the philosophy of Jean Piaget (1971), who views scientific knowledge as stemming "neither from sensation nor from perception alone but from the entire action..." Piaget notes that "the characteristic of intelligence is not to contemplate but to "transform" and its mechanism is essentially operatory. ... We only know an object by acting on it and transforming it..."

Good teachers, constructivist or otherwise, given an environment in which they can allow free rein to a child's thirst for understanding, will try to focus the child's quest by providing appropriate stimuli and feedback. The teacher's goal in this collaborative endeavor is not so much to instruct as to educate—*educere*, lead forward—in the belief that the child should not be left to flounder in the discovery of knowledge.

Unfortunately, most teachers are not given "an environment in which they can allow free rein to a child's thirst for understanding." Classes are typically too large to accommodate significant individualized instruction. For this reason constructivism, and the many other powerful theories of learning such as those advocated by Dewey, Montessori, Piaget, and Bruner, have been paid no more than lip-service in public, or even most private, systems of education.

However, teacher-pupil ratios are falling, and technology is becoming sufficiently sophisticated to take on more and more of the functions of guided individual student learning. This evolutionary process is showing promise of eventually leading to a learning environment in which teachers—rather than being the source of knowledge—will manage, guide, motivate, and coordinate. Students will actively, individually or in small groups, discover knowledge in the context of the Montessorian "prepared environment" of the technology-rich classrooms of tomorrow.

This is already happening in a fair sprinkling of schools worldwide, including some of those profiled in this book. But let us examine more closely the importance of individualized education in general and, more specifically, the impact of the ideas of Doctor Maria Montessori in the realm of individualized education.

THE IMPORTANCE OF INDIVIDUALIZED EDUCATION

The extent to which individuals reach their potential as human beings is partially dependent on cultural expectations. The history of education tells the unfortunate story of the many systems that operated under the assumption that certain groups of individuals were less academically able than others. This attitude was able to persist because the education systems themselves were founded on arbitrary definitions of what constitutes "academic ability."

To some extent this is understandable, even though it is inexcusable. As explained in the previous section, education has a pragmatic emphasis—where success is measured by how profitable the graduate becomes in adult life. But a more appropriate and equitable definition of academic ability begins with the assumption that every individual *is* academically able, regardless of whether that ability will yield a profitable return. The school's responsibility is to determine in what respects this is true for each and every student. As one teacher put it: "The question is not how smart the child is, but how the child is smart."

The school as lifelong information system succeeds or fails to the extent that it helps individual students achieve their potential as human beings. "You cannot teach a man anything," observed Galileo; "you can only help him to find it within himself." We may look to numbers as a measure of performance because we have no more convenient way of judging success. So we rate schools and individuals based on numerical criteria. But in the end, true success can only be measured in terms of the individual's self-fulfillment.

Education must therefore continue to broaden its definition of what constitutes a successful student, for no two graduates should be expected to be equally or identically affected by what goes on in schools.

Each individual has a unique and valuable contribution to make. Education's task—with the help of students, parents, teachers, administrators, and the local community— is to nurture the unique excellence in each and every one of us. Traditional methodologies developed to cope with large group instruction tend to overlook individual needs. The underlying argument of this book, however, has been that individualized education is more likely to be promoted in classrooms where teachers are given the opportunity to design and maintain resource-rich, computer-integrated learning environments.

The computer thus can be the key that opens the door to individualized, student-centered, constructivist learning. Let us examine this more closely, and then consider some caveats about the use of computers in the classroom.

When Should the Computer Be Used in the Classroom?

The human mind is extraordinarily complex. Tufte (1990) captures this complexity when he describes the information processing skills of the human intellect:

> "We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, structure, highlight, group, pair, merge, harmonize, synthesize, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, refine, abstract, scan, look into, idealize, isolate, discriminate, distinguish, screen, sort, pick over, group, pigeonhole, integrate, blend, average, filter, lump, skip, smooth, chunk, inspect,

> approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flip through, browse, glance into, leaf through, skim, list, glean, synopsize, winnow wheat from chaff, and separate the sheep from the goats."

It is unreasonable to expect children to grow intellectually in some straightened environment where variety of learning experience is reduced to the bare minimum. This is something that a good teacher intuitively understands. But the good teacher also intuitively understands that effective learning requires discipline, concentration, periods of peace and quiet, and a sense of order.

Unfortunately, it is often easier for a computer to be used as a pacifier than as a tool for solid learning. Many applications of computers in schools today have the primary objective of occupying the children for a period of time, regardless of learning outcomes. In light of this it will be useful to examine when and how the computer should and should not be used for teaching and learning.

While it is never indispensable, the computer is an appropriate tool to use for teaching and learning. Here we will review a sample selection of such situations.

Computer-Based Learning Enables the Teacher to Tailor the Learning Situation to Suit Individual Student Needs

Turkle (1984) recognizes the value of the computer, "the second self," for those many learning situations where the child's personality, age, and style of learning calls for an individualized approach. This puts the onus on the teacher to diagnose each individual child's information needs and style of learning, and then prescribe appropriate learning opportunities.

While not impossible, this is difficult to do in a traditional classroom where the large class size coupled with a limited set of learning materials makes customized instruction an elusive dream. In the computerized classroom, however, access to a wide variety of educational software enables the teacher and student together to select effective computer-based learning situations, especially if the teacher has the training, experience, and motivation to know each child well.

There is no substitute for this. As Jean Jacques Rousseau observed in the preface to his 1762 novel *Emile:* "The first thing is to study your pupils more, for it is very certain that you do not know them." While it is true that children will apply themselves diligently when their mind is engaged, it is not true that, unassisted, they will always select activities that will further their education. So they need the teacher's help.

Computer-Based Learning Suits Children's Desire to Control Their Own Learning

Piaget (1926) observed that at least up to the age of about 7 children are essentially egocentric in their thinking, and therefore also in their use of language. As Piaget states: "The functions of language are complex, and it is futile to attempt to reduce them all to one—that of communicating thought .... For the most part [children up to the age of about 7] are only talking to themselves." A corollary of this, with pertinence to the importance of well-programmed computer-based learning, is the idea that, as Piaget puts it, "The audience is there simply *as a stimulus"* (emphasis added).

The methodologies applied in the schools of Dr. Maria Montessori (Fig. 13.5) are also based on a philosophy of education which recognizes the children's preference for control over their own learning. One has only to consider some of the various "discoveries"[1] that she made about the learning modes of the children with whom she worked (Standing, 1962).

Fig. 13.5 Dr. Maria Montessori (1870-1952)

As you consider each of the Montessori discoveries that follow, consider how each might be borne out and amplified in the "prepared environment" of appropriate computer-based learning. Some of the discoveries may come as a surprise if you are not an experienced teacher. If they run counter to your own experience, either as a student or as a teacher in training, suspend disbelief and keep an open mind as you read along. Rest assured that these discoveries are *re-discovered* every day, not just in classrooms modeled after Montessori's ideas, but in classrooms in general all over the world. The goal of education is to make these discoveries habitual.

Children have "amazing mental concentration" when their interest in anything is spontaneous Hence the importance of the "prepared environment" designed to naturally capture a child's interest and stimulate the desire to learn. This interest and desire to learn will be fostered in the classroom in which the children have access to a range of computer-based learning systems alongside other more traditional learning tools.

[1] "Discoveries" is in quotes because, of course, Dr. Montessori was by no means the first to recognize these realities of children in relation to learning. Nor was she the last. They did, however, take her by surprise; thus for her they were discoveries, as they may be for you, too. Teachers everyday make these same discoveries working with individual children or with groups. They rejoice when they do because it means that the children have become responsible for their own learning, thus taking the awesome burden for that off the teachers' shoulders.

Children "love repetition of material even when it is already known" Montessori describes this as a "profound psychological need" during the early years of a child's education. The appropriately programmed computer can be an invaluable vehicle for such repetitive activity because, unlike teachers, it never gets tired. One has only to watch children playing video games to know how easily and exhaustively children are motivated by engaging computer-based activities. When these activities have the added value of being educationally constructive it seems sensible to take advantage of the computer's motivational capabilities.

Children love freedom of choice when it comes to activities This is why Montessori went to such pains to understand and define the appropriate "prepared environment" for her students depending on the developmental stage that they were at. The classroom was set up with carefully constructed learning aids (called "didactic materials") of all kinds. The children were left free to decide what they wanted to work at or, for that matter, they could decide to do nothing at all. Of course, Montessori recognized that one is only free when one has options, otherwise one has no choice; hence the considerable variety of stimulating learning materials that she prescribed for her classrooms.

It is beyond the scope of this book to detail all the "didactic materials" used in the Montessori classroom. The reader is referred to any of the many excellent texts on learning theory for a more extensive description of the Montessori Method. Standing (1962) would be a good place to start. Rita Kramer's "Maria Montessori: A Biography," (Putnam Books, 1976) is another excellent, honest appraisal of Montessori's place in the history of education.

The didactic materials can be purchased from school suppliers or you can, of course, construct them yourself. With the computer in mind, didactic materials in the form of the growing selection of learning software would become part of the "prepared environment" in which the child could freely choose among the set of available activities.

Children prefer work to play The distinction between work and play is an artificial one. Culture to a large extent determines what we will perceive as either one or the other. For example, Winston Churchill liked to lay brick walls as a form of relaxation. If we create and maintain a learning environment where the children can enjoy what they are doing—which includes the option to do nothing—they will be more likely to busy themselves with useful activities. As one teacher observed: "Kids who have fun will work harder." Even Plato, that advocate of mental discipline as the basis for learning (Bigge, 1982), commented that "early education [should] be a sort of amusement; [for] you will then be better able to find out the natural bent."

Naturally, when work is perceived as play it will be preferred over activities that are perceived as less enjoyable. Teachers who have the opportunity to work with small groups of, let us say, ten or fewer students know how much easier it is to maintain a pleasant, flexible, and child-oriented learning environment. One of the problems in most classrooms is that the teacher-pupil ratio is still so high that it is next to impossible to provide an environment where the children can be allowed to "do what they want." So teachers

perpetuate the methodology they themselves endured through their years of schooling, a methodology that depends largely on the principle of regimentation.

The computerized classroom can go a long way to overcoming the problem of numbers. Classes can be more easily broken up into small groups, or individuals can be left to work on their own. The teacher becomes the facilitator of learning rather than the source of it.

Children love silence When we are trying to think, we usually find noise a distraction. Children will be the first to appreciate the opportunity to work undisturbed. This is why teachers place so much emphasis on discipline in class; not to stifle intellectual activity, but to maintain an environment in which it can flourish. Classrooms in which the children have access to computer-based learning systems, while still needing adult supervision, will often not need much of it because the children are engaged.

Children "explode into writing" once they have learned the letters of the alphabet and the sounds they represent Children do not need to be taught to write. The *Writing To Read* program developed by Dr. John Henry Martin and sponsored by IBM would seem to contradict this approach. But in fact, as this discovery bears out, there is no contradiction. The Montessori children first learn the letters and the sounds they represent; this leads naturally to the discovery of an ability to construct written words. It is only several months later do they learn to read those written words.

Children are spontaneously self-disciplined—and extremely obedient—in a Montessori environment. The reason is simple: the children are engaged in activities of their own choice which absorb their attention to the extent of obviating much of the need for externally applied discipline. Standing (1962) calls it a "cosmic discipline." He quotes Montessori herself as saying: "The quiet in the class when the children were at work was complete and moving. No one had enforced it; and what is more, no one could have obtained it by external means." Teachers who have had experience working with children in *well-planned, well-designed* computer-based learning environments can corroborate this "discovery" for themselves.

Software that has been carefully crafted and selected by trained and experienced educationists for the purpose of stimulating learning in children will, in the hands of those children—at their own pace and in their own time—achieve the same effect as a teacher for many learning situations. There are, moreover, significant advantages to the computer-based learning stimulus:

- The child can have 100% of the computer's attention.
- The computer frees up the teacher for important interaction with other children who may need more help.
- The computer-based learning system gives the child complete control over the pace of learning. This echoes the aspiration of the philosopher George Bernard Shaw who said: "What we want is to see the child in pursuit of knowledge, not knowledge in pursuit of the child."
- In the long run computer-based learning will realize significant economies as the cost of teachers continues to rise while the cost of computing falls.

The Computer Is an Invaluable Tool for Classroom Management

We already discussed this aspect of computing in chapter 5. There we noted the value of the computer as a tool to assist in *developing useful templates* for letters, forms, ditto masters, and so forth. We also saw that the computer is a major time saver when it comes to specifying curricula, preparing syllabi, planning lessons, and *preparing learning materials of all kinds.*

Test preparation and evaluation also can be assisted by the computer. More and more text books come with test generation software which takes much of the drudgery out of preparing tests.

The computer is useful as *a visual aid in its own right*. Soft copy materials can be prepared on the computer and then projected directly onto a large screen. Student assessment and guidance is supported by controlled access to a database of student information, which more and more schools maintain.

Finally, *communication with parents* is facilitated by online tools such as those described in chapters 7 and 8 and which help with attendance management, dissemination of notices of all kinds (including what assignments the children have been set), and various other pedagogical outcomes that are best handled by interaction with parents (Bauch, 1990).

The Computer Is the Best Writing Implement Yet Invented

The research profiled in chapter 1 overwhelmingly concluded that the word processor and the tools associated with it had a significant effect on the quality of student writing. This is bound to spill over into other areas of the curriculum since writing is fundamental to the acquisition, reinforcement, and assimilation of knowledge in all fields.

At a conference on *Writing Across the Curriculum* offered at Pennsylvania State University in 1987, the keynote address, given by Dr. James R. Squire, was entitled 'Writing to Learn.' The message was simple: the act of writing, of organizing ideas with a view to communicating to others, does more than simply demonstrate what knowledge we have. It reinforces, transforms, and activates that knowledge.

Writing is a powerful, often painstaking process the execution of which is perhaps the most educational cognitive activity in which we, and our students, can be engaged. And it is a process appropriate to all subjects right across the curriculum.

Word Processing to Learn If it is true that writing contributes significantly to the assimilation of knowledge, and if it is true that the computer is the most versatile writing implement yet invented, then it follows that efforts should be expended at all levels of education to make the facility of computerized word processing available to all students. The beauty of this goal is that it is based on the simple, but powerful, concept—that of "Writing to Learn."

As Mageau (1992) reflected in an editorial to Electronic Learning: "For the rest of the world for whom writing is a painful and difficult process, being given a revision tool like a word processor is like being given the key to your jail cell." Mageau goes on to point out that the word processor does not magically turn a poor writer into a good one. Only people can do that.

The word processor removes one barrier to the process—the physical difficulty of revision. "What ultimately helps non-writers to write—and rewrite," says Mageau, "is a good teacher who enables

students to see that their voice, their ideas, and their ways of thinking are worth exploring and sharing with others."

CAVEATS REGARDING COMPUTER USE IN THE CLASSROOM

Computers Should Not Be Used For Purely Passive Learning

Computer learning should invite interaction. This interaction can take many forms, amongst which might be the following:

- Responding to questions.
- Finding answers to questions.
- Writing.
- Doing math.
- Preparing and giving presentations.
- Communicating and collaborating with classmates and others.
- Reacting to, and interacting with, simulations.
- Browsing databases such as the World Wide Web containing text, video, and audio material—always, with young children, under the careful guidance of the well-prepared teacher.
- Accessing and processing information for inclusion in other research products.

A Computer Does Not Take the Craft Out of Writing

At several points in this text we have considered the beneficial effects of word processing on writing. There is a danger, however, of too much emphasis being put on the appearance of students' work, rather than on the content. Hill (1992) quotes Hilary Cowan, instructional technology program director for Kanawha County Schools in West Virginia, who observed: "It's important that the *process* in process writing isn't skipped. I think it's too easy on a word processor to go from step one to the final finished product with little thought in between."

A carpenter must still understand the nature of wood, and have the knowledge and skills to produce good work, even though he or she will make use of powerful tools to expedite the work.

Spelling Checkers Do Not Have All the Answers

Spelling checkers are very useful for picking up misspelled or mis-typed words. However, they are no good for misused homonyms (too, to, two) and, of course, they cannot account for ignorance (as, for example, when a student takes something for “granite” when it should be taken for “granted").

The dictionary that accompanies a spelling checker cannot contain every word under the sun. Students have to be told that if a word is flagged as not appearing in the dictionary, this does not mean the word has been misspelled. It simply may not be in the dictionary.

Many spelling checkers will offer suggestions of alternative words for those it cannot find in the online dictionary. This can be hazardous to some students' academic health! Sometimes a student

will substitute an incorrect word just because it has been suggested by the spelling checker. For example, a student who was writing a story about "Samson and Delilah" wrote instead about "*Salmon* and Delilah." As it happens, proper names are usually omitted from online dictionaries, and sure enough the first alternative suggestion made by the spelling checker for the unknown Samson was *Salmon*!

Computers Cannot Replace the Teacher's Skill and Experience

As already emphasized throughout this text, computers do not replace teachers. They are tools that teachers use to directly or indirectly work more effectively with children. Teachers use the computer directly by selecting programs that will address individual and group learning needs based on experience. Teachers use the computer indirectly by taking on new roles in the classroom as computer-based learning takes over some of the traditional teaching tasks.

CAI can add significantly to the quality of the learning experience, and a skilled teacher will capitalize on the help that technology provides by investing his or her own efforts in a higher level of individual or group-specific attention. But the computer will not replace the teacher any time soon.

Computers Should Not Be Allowed to Take Away From the Teacher's Responsibility for Careful Class Preparation

The fact that teaching tasks such as preparation (of audio-visual aids, tests, worksheets, and so forth) is simplified should not take away from the teacher's responsibility to plan with the same care, whether or not the computer is used.

For example, computerized test banks make test generation a snap, but teachers still need to consider the design of the tests they prepare. Tests that include only short essay responses may handicap those students who are not good at explaining what they know in the sometimes frantic time constraints of an in-class test. If the objective of short essay tests is to determine whether the student can *write*, then it is a different matter, though it is debatable whether a timed test is an appropriate method to assess writing ability.

Another problem with test generators is the quality or otherwise of the questions that are provided in the database. Are the questions unambiguous? Do the questions adequately test the material that is the subject-matter? Have the questions been chosen and/or phrased in such a way as to not favor one group or another on the basis of race, gender, or ethnic background? If the answer set is generated by the software, are the answers to the questions correct? This is especially relevant for single correct answer questions such as matching, multiple choice, fill in the blanks, or true/false.

When the questions are supplied along with the software that accompanies a text, a teacher must verify the accuracy and appropriateness of every question included in a test. There is no guarantee that each time a topic is covered the same emphasis is given to different components of the topic, so questions may well need to be revised from semester to semester, even from class to class.

As it happens, the computer makes it easier to update tests. Thus, customizing tests for different learning situations should be the rule rather than the exception. In the same way, computer-based tools should make it easier for teachers to keep all their teaching materials current. Computers,

therefore, should be seen as providing an opportunity for *seeking* excellence, rather than as an opportunity to short-circuit it.

The Computer Can Be an Excellent Child Minder, but that is Not How It Should be Used

This is often a question of perception. Assuming that the software available for use in schools is selected on the basis of its educational value, it is possible to argue that any time the students spend using it they are in a learning mode. But it may not be an appropriate learning mode. So the teacher must plan for productive student use of the technology. In other words, students should not be let loose on the machines with the primary purpose of pacifying them.

Learning theory is the foundation for teaching. It goes without saying that the incorporation of the computer into the curriculum should in no sense take away from the teacher's commitment to creating and managing an environment in which learning is most likely. Fancy schmancy software that carries the "educational" label may not be effective in achieving its stated "educational" goals—even if the children love using it.

Pacification is not learning. Even when a computer-based system has proved effective elsewhere, with other children in other learning environments, it does not abrogate the teacher's responsibility to monitor the impact of that same system on a particular class of students with a view to assessing learning outcomes.

By the same token, a teacher who incorporates a computer-based learning system into the curriculum has the responsibility to validate that system in the context of the learning theory that is the intellectual foundation of teaching. Software evaluation, which we considered in chapter 6, is thus an important skill. The process of evaluation presupposes familiarity with the various theories that have arisen from the study of learning.

Computers Should Not Be Used Purely as Electronic Page Turners

This is a common complaint of teachers who are unenthusiastic about computer-based learning. The complaint usually stems either from ignorance or from previous unfortunate experience of poorly designed CAI. Certainly, this complaint is justified if the computer is used for no other purpose than to work linearly, page by page, through some passive study of textual material.

But this is rarely the case with CAI, especially that which involves multidimensional access to varied types of data—text, images, video, sound—as in multimedia systems. Nor is it the case when the study involves the accessing of text in a non-linear fashion, as in textual database research where the student moves from one text to another following an associational path linked by key words.

Can you think of other ways in which computers should *not* be used in education?

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

What, then, are some of the prerequisites to successful implementation of a technology program? In chapter 1 we briefly looked at the Ten Pillars of Successful Technology Integration. It is time

to examine this set of pre-requisites in more detail. Table. 13.1 lists them and following the table is a discussion of each Pillar.

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

Table 13.1 The Ten Pillars of Success

Let us examine each of these pillars of success one by one.

Pillar 1: Leadership provides active and committed support--financial, logistical, and moral

A technology program is only going to succeed when school boards, school superintendents, and school principals commit to it in word and deed. As already noted, a well-developed grant proposal will include written commitments of support from those who hold the local reins of power. This support would take the form of practical allocations in terms of all necessary release time and training for those teachers and administrators who are responsible for implementing a grant.

Lumley (1992) quotes teachers as saying: "If we don't receive active leadership and support from our principal and superintendent, technology just doesn't happen!" Lumley then goes on to itemize the characteristics of leadership required of effective superintendents and principals: these leaders have to be planners, visionaries, supporters, facilitators, and decision-makers.

This author has been involved in IT training for teachers in a school district where the superintendent attended every single one of the 14 three-hour-long classes AND insisted that all his principals did the same! Now that’s leadership! The superintendent walked the walk, and it made all the difference.

Pillar 2: Selling is better than telling

The best leadership establishes an environment in which expected outcomes occur spontaneously. Technology should never be forced on teachers; its use should never come as a mandate from on high. Teachers, unfortunately, are no different than other professionals when it comes to sabotaging systems that they do not like and do not want.

So teachers must be given the opportunity to prepare for the kind of change that computer technology brings. This is a major challenge, and one that has been sadly neglected in too many school districts during the first decade and a half of computer use in schools. Considering how carelessly computer systems have been introduced, it is hardly surprising that some teachers have resisted accommodating them in their curriculum.

The best leadership therefore enables teachers to become the best that they can be through consultation, collaboration, communication, support, respect, and encouragement. The best leadership must also work to supply and maintain an "appropriate environment" that will function as fertile ground for educationally sound outcomes.

Teachers are only one variable in a complex educational equation. Just as students need teachers to help them establish a "prepared environment" for learning, so teachers need an administration that will be committed to helping them help the students. As the principal at a school founded by Maggie Cromer expresses it so well: "Schools are institutions where people of good will work together for the children."

Pillar 3: Invest in and train a core team of teacher-computerists

A teacher-computerist is a person who is committed to using computer-based educational technology and who has been given the opportunity to gain a sufficiently high level of expertise to qualify them to act as role models, advisors, and trouble shooters in matters to do with computer-based educational technology. In every school there should be one or more teacher-computerists, the number depending on the size of the school and, of course, on the school's commitment to educational computing.

Teacher-computerists should be given adequate release time to fulfill the following roles and tasks:

- to work with other teachers, as individuals or in groups, introducing them to new systems, arranging product demonstrations and helping them with any technical or pedagogical problems that may arise;
- to work with administration, planning near and long range computing strategies and mediating on behalf of teachers to help ensure that their needs are addressed;
- to work with vendors (suppliers of hardware and software), organizing product demonstrations, making sure that products are delivered as ordered and that warranties are negotiated and fulfilled.

Teachers are the ideal people to work with other teachers because they understand their needs. Teachers who are also computerists will be further suited to help their colleagues learn about computers because they are trained as teachers, and have experience working with computing

novices. They are therefore less likely to frighten off other teachers who may be timid about getting into the technology.

Pillar 4: Recognize that technological change is fast and that keeping up to date is challenging and essential

Preparation that involves computer technology puts greater demands on the teacher in terms of time than more traditional methodologies. Typically, teachers K-12 have far too little time to prepare and follow-up on classes. It is all very well to say that they have those long summers off when they could be planning new lessons, learning new methodologies and incorporating them into their curricula. Many teachers already do this. But long-range (what is also called "remote") preparation can only accomplish so much. Immediate preparation, designing classes to meet the needs of today's students *today*, must be done in the context of the live situation once the semester is underway.

Thus, it is tempting for teachers to take the easy route, teaching as they were taught, teaching the old-fashioned way, with barely more than chalk and talk by way of a methodology. School districts must therefore provide teachers with every opportunity to stay abreast of advances in technology and, more importantly, must give the teachers time to integrate teaching and learning technologies into the curriculum.

Pillar 5: All teachers receive on-going training

Too many schools put computers in the hands of the students and then magically expect the teachers to take advantage of the situation in their teaching. As Elmer-Dewitt (1991) observed, teachers should be the first to receive hardware and software systems and should be the first to be trained to use it. The teachers are the leaders in the classroom. How can they take advantage of the first of these secrets of successful integration of technology into their curricula (*Active support must come from the top*) unless they have sufficient knowledge and skill to feel that they are in control?

As long ago as 1989, the Shoreline Public Schools gave a computer to each of its approximately 600 teachers (Schlumpf, 1991). The school district began this "Apple for the Teacher" program because it believed in "giving teachers direct access to their own computer [as] the most logical step towards facilitating the professional development and maintaining the excellence of [their] staff. Teachers were to feel free to take the computers home if they so wished, and to that end carrying cases were provided, too.

At schools such as the Lausanne Collegiate School in Memphis, Tennessee, Lorrie Jackson organizes half-hour “Tuesday Techtorials” to which all teachers are invited and which provide hands-on training throughout the school year.

Pillar 6: All teachers receive on-going technical support

Technical support should be on site and on demand. To quote Debbie Drewien, Instructional Technology Specialist for the Blaine County School District in Idaho, USA: “I whole-heartedly support [the] view that being on-site where you can respond to teachers' needs Just-In-Time and build those relationships with them so that they are willing to invite you in is so important. They

will rarely call you if you are [squirreled away somewhere] at the district office. Out of "site", out of mind (if you'll pardon the pun)!

Sometimes an adversarial relationship can develop between the technology support team and the teachers because the tech support team may be understaffed and overwhelmed with problems that arise on a daily basis. Also, tech support may not understand teachers' needs because they may not themselves be trained teachers. But Jeff Hogan, Instructional Technology Resource Teacher at the Blankner School in Orlando, Florida, USA puts it well when he says: "In the best possible world (which is the one I live in because I choose to make it the best) instructional technology (IT) *is* faculty and staff. We are a team and we do it all for the students."

Pillar 7: Use it or lose it

On-going training is important for two reasons. First, computer technology is notorious for the pace of change that has accompanied its development. Second, anxiety generally accompanies this change. The technology is advancing so rapidly that faculty skills quickly become obsolete as new hardware and/or software systems are introduced. Commitment to a technology-based teaching and learning program will wane unless the teachers are routinely helped with the process of learning new skills.

Practice makes perfect, as they say. Lack of practice can easily lead to the loss of previously acquired skills.

Anxiety is a human factor which can have both good and bad effects. The best kind of anxiety, such as that experienced by a teacher working with new material or with a new class—or with new technology, for that matter—improves preparation, raises concentration levels, and gives the spark of life to the new experience. This good anxiety is welcomed by good teachers because they know it is productive for all concerned.

But anxiety can also be counter-productive, causing retreat from progress into the secure shell of the humdrum. This bad anxiety is often triggered by the careless introduction of innovative methodologies. Bracey (1988) cites the research of Honeyman and Warren of Lehigh and Kansas State universities respectively which showed that teachers needed on average a minimum of 30 contact hours with computers before they felt they had overcome initial anxiety about using them.

Bracey (1988) went on to note the findings of Wedman and Heller at the University of Northern Iowa that teachers need to overcome their anxiety around computers first, without regard for how the technology might be applied in teaching and learning. An added level of anxiety can easily accompany using the technology in an actual classroom full of students who might quite possibly know more about computers than the teacher does.

Bracey concluded that technological innovation takes time and that training programs should take into account the negative potential for anxiety induced by unreasonable expectations. Capper (1988) corroborates this conclusion and emphasizes that even experienced teachers who are new to computer technology should be given ample opportunity to feel at ease using the equipment before requiring them to prepare specifically for the incorporation of the computer into their curriculum.

Pillar 8: Parents and students are actively involved in the evolutionary process

There should be continuity between home and school. This applies to all aspects of education. Parents should feel that their child's classroom is *their* classroom, too. Today, in the United States at least, more and more parents have an online computer for their child in the home. But even where this is not the case, parents should at least be provided with feedback on the existence and effectiveness of a technology program in the child's classroom. Schools—administration and faculty—have to appreciate the value of getting parents directly or indirectly involved in the classroom.

Most parents are passive in this regard, especially after the first year or two of a child's formal education. The best schools appreciate the power of parental involvement and thus actively foster close relationships between parents and the school for students of all ages—even at the college level. Most schools have PTAs, many have parent-teacher days/evenings, some structure routine home visits by teachers, and in at least a few schools the principal accompanies teachers when they visit the home of one of their students.

Computer technology is now being used routinely to promote contact and communication between the school and the home. As was discussed in chapter 7, parents and teachers can maintain close contact on a daily basis via computer/telephone system hookups (Bauch, 1991). There are schools that not only put a computer on every teacher's desk, but they also install a phone and a modem alongside that computer which allows parents and students to interact with teachers over electronic and voice mail systems.

Information has been defined as "a reduction in uncertainty" (Shannon & Weaver, 1949). Effective communication enabled by computer-based technology can help remove much of the uncertainty that surrounds many parents' perceptions of the education their children are getting in school.

Pillar 9: There must be planned and systematic financial investment in technology-integrated teaching and learning

In times of economic adversity, school districts should resist the temptation to trim the educational technology budget. Modern computer-based instructional technologies rapidly become obsolete, so a commitment to funding technology-integrated teaching and learning is a necessity, not an option. This commitment has to be seen as long term, with careful planning to ensure that money is well-spent.

Pillar 10: Technology is for all and involves all in the process of lifelong learning

Children today are growing up with modern computer-based technology as part and parcel of their lives. They are digital natives; they cannot imagine their lives without access to technology. Learning at school and at home can be seamless and integrated when the technology is made available in both environments. Parents, children, teachers and administrators will all work towards enabling learning as something which children do not "switch off" when they leave the classroom, but rather relish whenever opportunity allows.

By way of a summary of all of the above, listen to the words of a School District Technology Coordinator, Jeff Johnson of the Greendale School District in Wisconsin, USA, who has many years of experience on both sides of the technology fence—as a technology-using classroom teacher and as a professional devoted to helping teachers make the best use of technology in their classrooms.

> "The importance of planning cannot be overstated. When teachers or departments find some hardware or software that they feel would positively impact their curriculum and improve student achievement, there should be a process in place where several individuals/committees review the request. The teacher or department making the request should be able to document and demonstrate the educational value of the purchase. But that's not the only factor in considering whether or not the purchase should be made.
>
> "Frustrations with the IT staff often come from the IT staff's lack of understanding of teachers' needs and the view that The Network is the reason we all work in schools. I've been in this situation myself; it is very frustrating, as a teacher, to try to work with the IT director to help him or her understand why things need to be done in a different way.
>
> "On the other hand, district/school leaders needs to understand that demonstrating the educational value of the latest new hardware or software isn't the whole picture -- someone still has to install and support it. It is not unusual for a school district to add more technology in the classrooms and labs, thus raising the level of expectations for teachers and students, while actually reducing the number of people directly associated with tech support.
>
> "Where this is the case, there has to be a plan in place to improve teacher technology competencies along with a plan for managing technology. In other words, teachers should be expected to have some basic level of knowledge when it comes to using (and troubleshooting) technology. Support costs, too, need to be figured into the overall value of adding new technologies in schools. If the support piece is missing, it will be very frustrating for everyone, teachers and IT staff alike.
>
> This amounts to changing the way things are done in many school districts and, as we all know, change is hard. There are plenty of educators that resist change. Leadership is important here, as well as the understanding that change takes time."

In summary, then, leadership in schools could do worse than apply the secrets of success outlined above for establishing a prepared environment in which methodologies involving computer-based teaching and learning will flourish. Provide active support for technology-using teachers; take a non-dictatorial approach; make sure that every school has a core of teacher-computerists; ensure all necessary technical support; put the teachers' needs first; get the parents and students involved; ensure that an on-going technology training program is in place; and last, but not least, give the teachers time and freedom to restructure their curriculum around the technology.

TAKING CARE OF THE TEACHERS

It is important to recognize that realistically it is difficult for teachers to embrace this technology with any success unless they have time, ongoing training, and logistical and technical support. Let us briefly reflect on these prerequisites of successful integration of technology in the classroom.

Teachers Must Have Time

One of the long-standing anomalies of education systems worldwide has been that teachers in elementary and secondary schools spend much more time in class than teachers in post-secondary schools. Teachers in schools K-12 typically spend well over twice as many contact hours in class than their collegiate counterparts.

Why the discrepancy? Is it because K-12 teachers need less time to prepare their lessons? No. Is there less need for K-12 teachers to keep abreast of current knowledge in their field of academic interest? No. Do K-12 teachers expend less energy in the classroom? Of course not! But the anomaly persists.

A Nation at Risk merits careful reading, identifying as it does various problems with the American K-12 educational system and making specific recommendations to ameliorate those problems. The report recognizes "the dedication, against all odds, that keeps teachers serving in schools and colleges, even as the rewards diminish."

However, nowhere in the report was it suggested as part of a solution to these problems that teacher-pupil ratios should be reduced or that K-12 teachers should be allocated fewer contact hours a week. For every hour that a teacher teaches, he or she probably needs to commit three or four hours of pre- or post-class time for purposes of preparation, evaluation, and follow-up. But the reality is that elementary and secondary school teachers do not get adequate time for immediate preparation for class. They do not get adequate time for student assessment, performance evaluation, and follow-up. They do not get adequate time to establish and maintain crucial communication with the children's homes. And we have not begun to address the need for adequate time to update teaching methods in line with the latest developments in educational technology.

A Nation at Risk did note that "not enough of the academically able students are being attracted to teaching," and that "the professional working life of teachers is on the whole unacceptable." The report also recommended, among other things, that teachers should have "an 11-month contract" so as to "ensure time for curriculum and professional development ... and a more adequate level of teacher compensation." But extending the contract and raising the compensation does nothing to fundamentally change the way the schools are organized as far as the teachers are concerned. In fact, the burden on teachers might actually be increased if the report's recommendations for a longer school day (7 hours) and a longer school year (200 to 220 days) were implemented unless, at the same time, schools reduced teacher-pupil ratios and teaching loads.

Unfortunately, many teachers become disillusioned after a few years in a system that works against their best efforts to serve the students. According to Perelman (1990): "One teacher I

interviewed could have spoken for thousands when she said: "Why should I do anything different next year from what I did last year? Who cares?"

Are the ideas for reducing teacher-pupil ratios and contact hours practicable? Would the quality of education in our elementary and secondary schools improve if reforms such as these were implemented? Can computer technology come to the rescue by enabling a radical restructuring of the whole process of childhood education? Might the time indeed come, as discussed in chapters 7 and 8, when a fair proportion of a student's interaction with a teacher will be electronic ("videotronic") in a distance learning mode?

Teachers Must Have Ongoing Training

The need for ongoing training in educational technology is not met by a one day workshop once a semester. Ongoing training means at least a weekly structured session of, say, two to three hours during release time from what would otherwise be teaching responsibilities. This structured time would be spent working through online or video tutorials, or working one-on-one with the school's technology support staff, or working with similar age group and subject area teachers planning, designing and evaluating technology-integrated lessons. This would give teachers at least an even chance of making the transition to teaching with technology without compromising the quality of their day-to-day work with students.

The alternative is for things to remain the way they are, with some 80% of teachers doing no more than pay lip service to the call to update their teaching methods. This includes teachers who began the transition process by attending courses and workshops in the past, but whose enthusiasm has petered out once they realized how much ongoing effort was involved.

The components of training sessions should include the following:

- evaluating new software;
- giving or receiving training in newly acquired hardware or software;
- discussing with colleagues methodologies for incorporating new software into the curriculum;
- attending or giving district-wide workshops;
- attending or giving model lessons.

Teachers Must Have Logistical and Technical Support

Logistical support begets the need for technical support. Once schools commit to computer-based education, there is a logistical price to pay in terms of hardware, software, service contracts and computer supplies. Pillar (1992) and others have reported on the waste that follows when there is inadequate logistical and technical support for educational computing systems. Teachers should not expect to have to support and maintain computer systems. They already have too little time to learn how to use the computer and how to incorporate it into the curriculum.

The majority of teachers love to teach. They have worked hard to develop skills and methodologies which have proven successful. They recognize the value of computers in the classroom. The majority of teachers welcome the opportunity to integrate the computer into the curriculum and have the instincts and experience to put the technology to its best use. But

unfortunately the majority of teachers do not yet have a technology-rich classroom even if they wanted one. Nor do the majority of teachers get the time and funding to support their regular attendance at training seminars and conferences.

This is a situation which has to be remedied before schools can ever hope to adequately address the educational needs of students in an information age.

A FINAL WORD

The Great American educationist, John Dewey, should have the last word in this book. He was born before the American Civil War and lived to see the beginnings of the computer revolution. His perspective on education described here was first published in 1900, but it has a relevance now more than ever before, since the "media necessary to further the growth of the child" are being extended beyond most educators' wildest dreams.

John Dewey (October 20, 1859 to June 1, 1952)

> "The occupations and relationships of the home environment are not *specially* selected for the growth of the child; the main object is something else, and what the child can get out of them is incidental. Hence the need of a school. In this school the life of the child becomes the all-controlling aim. All the media necessary to further the growth of the child center there. Learning? certainly, but *living* primarily, and learning through and in relation to this living. When we take the life of the child [that has been] centered and organized in this way, we do not find that he is first of all a listening being; quite the contrary.
>
> "The statement so frequently made that education means "drawing out" is excellent, if we mean simply to contrast it with the process of pouring in. But, after all, it is difficult to connect the idea of drawing out with the ordinary doings of the child of three, four, seven, or eight years of age. He is already running over, spilling over, with activities of all kinds. He is not a purely latent being whom the adult has to approach with great caution and skill in order gradually to draw out some hidden germ of activity. The child is already intensely active, and the question of education is the question of taking hold of his activities, of giving them direction. Through direction, through organized use, they tend toward valuable results, instead of scattering or being left to merely impulsive expression.
>
> "If we keep this before us, the difficulty I find uppermost in the minds of many people regarding what is termed the new education is not so much solved as dissolved; it disappears. A question often asked is: If you begin with the child's ideas, impulses, and interests, all so crude, so random and scattering, so little refined or spiritualized, how is he going to get the necessary discipline, culture, and information? If there were no way open to us except to excite and indulge these impulses of the child, the question might well be asked. We should either have to ignore and repress the activities or else to humor them. *But if we have organization of equipment and materials, there is another path open to us.* We can direct the child's activities, giving them exercise along certain lines, and can thus lead up to the goal which logically stands at the end of the paths followed." (emphasis added) [1]

LOOKING BACK

There is not likely to be a revolution in education. Instead there will be a steady evolution that will involve integration of the new along with the tried and true. In this chapter we have reviewed traditional learning theories and methodologies in order to show that computer-based learning will be most effective if founded on principles and practices that have proved themselves over centuries of experience teaching children.

We have looked at ways in which the computer should and should not be used in the classroom. In all human achievement quality is characterized by careful preparation, conscientious implementation, and continuous evaluation, revision and reaffirmation of goals. The same must apply to the incorporation of computers into the curriculum.

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[1] John Dewey's book, *The Child and the Curriculum and The School and the Life of the Child*, was first published in 1900. The edition from which this quotation has been taken was published by Phoenix Books, University of Chicago Press, 1956.

We also reflected on the goals for education as set by the future workplace, in order to show how these goals can be effectively reached by schools which take advantage of technology in preparing students to take their place in the working world. Technology can help teachers to individualize education in a way that has been elusive up till now. When classes are large, it is difficult for even the best-willed teacher to attend adequately to individual student needs. But carefully integrated computer-based learning environments can both enable the teacher to provide individualized learning experiences and free up the teacher to work one-on-one with students.

LOOKING FORWARD

We have come to the end our journey in this book, which is where your journey in the computerized classroom of the Information Age begins. The fundamental content of this book has focused on practical matters related to computer use in teaching and learning. While there are many important philosophical and pedagogical issues that relate to the management of computer-based learning, there are also many skills that must first be learned—and then practiced so that the skills are not lost. Here is what the famous French tennis player, Jean Borotra, has to say about practice: "Never give it up, my friend. You must play a little every day." Likewise with technology. Use it or lose it, as they say.

You must keep your computing skills well-honed by attending workshops, conferences and seminars. The technology is charging ahead and is difficult to keep up with. If you are, or hope to be, in a school district where computer-based learning is supported by the community, take advantage of the opportunity to add to your skills and apply them in the classroom. Resolve to provide for your students the best-possible learning environment. As Eleanor Doan put it so well: “Good tools do not make a good teacher; but a good teacher makes good use of tools.”