Chapter 4: Educational Computing Environments

**Chapter Four**

Educational Computing Environments

Go to the place where the thing you wish to know is native; your best teacher is there. Where the thing you wish to know is so dominant that you must breathe its very atmosphere, there teaching is most thorough, and learning is most easy. You acquire a language most readily in the country where it is spoken; you study mineralogy best among miners; and so with everything else.

*Johann Wolfgang von Goethe (1749-1832)*

**LEARNING OUTCOMES**

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

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

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

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

"Sure. No Problem."

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

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

Wrong!
Time out...
Let's think about this...

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

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

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

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

• First Things First: On-going Training for the Teachers
  • ISTE Educational Technology Foundations for Teachers
• Safety First: Computers and Health
  • Extremely low frequency (ELF) electronic emissions
  • Carpal tunnel syndrome (CTS)
  • Ergonomics to the rescue
Chapter 4: Educational Computing Environments

- Other ergonomics-related considerations
- Summary of safety and ergonomics recommendations
- Computer Setup
  - Computers in the classroom
- The planning, design, and management of the computer lab or multiple-computer classroom
  - Recommendations for lab management

INTRODUCTION

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

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

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

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

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

Fig. 4.2 Dr. John Dewey (1859-1952)

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

Since really to satisfy an impulse or interest means to work it out, and working it out involves running up against obstacles, becoming acquainted with materials, exercising ingenuity, patience, persistence, alertness, it of necessity involves discipline—ordering or power—and supplies knowledge. Take the example of the little child who wants to make a box. ... If the child realizes his instinct and makes the
Chapter 4: Educational Computing Environments

box, there is plenty of opportunity to gain discipline and perseverance, to exercise effort in overcoming obstacles, and to attain as well a great deal of information.

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

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

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

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

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

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

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

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

FIRST THINGS FIRST: ON-GOING TRAINING FOR THE TEACHERS

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

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

**ISTE Educational Technology Foundations for Teachers**

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

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

For this reason, the society has spearheaded the National Educational Technology Standards (NETS) project "to enable stakeholders in PreK-12 education to develop national standards for educational uses of technology that facilitate school improvement in the United States. The NETS Project works to define standards for students, integrating curriculum technology, technology support, and standards for student assessment and evaluation of technology use."
Chapter 4: Educational Computing Environments

ISTE's published standards\(^1\) include a listing of the National Educational Technology Foundations for All Teachers, called “NETS for Teachers.” The full set of ISTE's educational technology foundations for teachers may be found at the following web URL:


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

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

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

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

   a. promote, support, and model creative and innovative thinking and inventiveness.

   b. engage students in exploring real-world issues and solving authentic problems using digital tools and resources.

   c. promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes.

   d. model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments.

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

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

   a. design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity.

   b. develop technology-enriched learning environments that enable all students to pursue their individual curiosities and become active participants in setting their

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\(^1\) The society's publications, ISTE Update, The Computing Teacher, and Journal of Research on Computing in Education, are listed in Appendix B.
Chapter 4: Educational Computing Environments

own educational goals, managing their own learning, and assessing their own progress.

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

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

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

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

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

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

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

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

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

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

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

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

5. Engage in Professional Growth and Leadership
Teachers continuously improve their professional practice, model lifelong learning, and exhibit leadership in their school and professional community by promoting and demonstrating the effective use of digital tools and resources. Teachers:
Chapter 4: Educational Computing Environments

a. participate in local and global learning communities to explore creative applications of technology to improve student learning.

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

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

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

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

SAFETY FIRST: COMPUTERS AND HEALTH

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

Extremely Low Frequency (ELF) Electronic Emissions

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

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

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

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

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

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

**Carpal Tunnel Syndrome (CTS)**

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

![Fig. 4.3 Carpal tunnel syndrome (CTS)](image)

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

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

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

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

Ergonomics to the rescue

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

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

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

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

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

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

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

The methodology involves encouraging the "patient"—computer user, musician, or whoever is vulnerable to repetitive stress injury—to find the natural position of the hands or arms. Beginning "hands off," the user moves back from the keyboard and relaxes the hands and arms. The idea is to find the most comfortable position possible.
Chapter 4: Educational Computing Environments

This is often with the hands and forearms resting in the lap. With this awareness in mind, the user can then return to the keyboard, where he or she learns to sense discomfort early, and to seek the most comfortable position as frequently as necessary in order to avoid the long term disability that would otherwise come with repetitive stress.

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

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

**Other Ergonomics-Related Considerations**

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

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

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

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

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

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

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

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

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

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

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

The keyboard, which is usually connected by a cable to the system unit, should be capable of being moved around independently of the system unit. A wireless keyboard and mouse would be the ideal since there would be no wiring straggling across the surface of the workstation table top and getting caught up in other equipment. Whether
Chapter 4: Educational Computing Environments

or not wireless keyboards and mice (mouses?) become standard in schools remains to be seen. After all, they would more easily "run away" if not tethered to the machine!

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

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

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

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

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

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

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

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

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

**Summary of Safety and Ergonomics Recommendations**

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

- Provide chairs that can be adjusted for height so that users can position the top edge of the computer monitor at, or slightly below, eye level. This encourages users to hold the head in a comfortable upright position, thus taking pressure off the neck and upper back.

- The chairs should have adjustable back rests for support of the lower and middle back.

- The optimal background color for reading text is white. This reduces eye strain. So when preparing learning materials that will be shown on the screen, teachers should make the background of such displays white.

- Tilt the screen (with wedges if necessary) to cut glare from natural or artificial light sources in the room.

- Computer keyboards should be detachable so that the user can sit back from the monitor and also adjust the orientation of the keyboard for maximum comfort.

- Keyboards should be adjustable for height so as to fit the position of the arm and wrist, which will vary from person to person.

- Put some kind of padding along the front edge of the keyboard and the mouse, on which the user's wrists can rest. Folded up toweling will do for this purpose.

- Use tables that are deep enough to allow the user to be at least an adult arm's length from the computer monitor. This reduces the risk of side effects from ELF electronic emissions.

- The tables should be large enough to provide adequate work space for writing and other activities.

- Use non-reflective and sound-proofed materials for all surfaces in the room to cut down on glare and noise.
Chapter 4: Educational Computing Environments

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

COMPUTER SETUP

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

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

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

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

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

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

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

Computers in the Classroom

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

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

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

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

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

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

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

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

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

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

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

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

![Fig. 4.5 Workstation that is easily adjusted for accessibility](image)

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

- Each computer in a school must have antiviral software installed on the hard drive. An example of such software is Symantec Corporation's *Norton Antivirus* virus
protection package. Computer viruses and their antidote, vaccines, will be discussed in some depth in chapter 13.

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

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

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

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

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

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

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

Step 1: Understand the problem

Plan ahead, and start planning as early as possible.

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

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

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

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

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

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

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

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

Step 2: Devise a plan

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

Step 3: Carry out the plan

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

Step 4: Look back

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

Recommendations for Lab or Multi-Computer Classroom Management

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

- Every lab should have full time technical support. Heavily used computer equipment needs constant maintenance. Students will also need support for hardware and software use. The best people to take care of the latter are trained and supervised student volunteers who acquire valuable social and leadership skills in such roles.

- Do not forget about students with disabilities, a subject we already touched on.

- If you have a choice, connect the computers in the lab to one or two high speed laser printers. This will work out much better than having one printer per machine. It is much easier, for example, to maintain and support one or two quiet, high-speed networked laser printers than 10 or 20 slow and noisy dot matrix printers. It is also less expensive.

- Think about an Uninterruptible Power Supply (UPS). This is no longer too expensive an outlay, and can save much grief, especially in areas of the country where power outages are frequent. It only takes a fraction of a second to lose hours of work. You may need to think about installing this UPS option in the lab. You should still display recommendations for correct computer use as recommended above. (See figure 4.8 above). These should include the all-important recommendation to remind students to back up their work regularly.
Chapter 4: Educational Computing Environments

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

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

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

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

Fig. 4.7 A multiple computer classroom

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

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

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

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

LOOKING FORWARD

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

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