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Some "Do's" and "Don't's" for Using Computers in Science Instruction

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Learning science is the goal: Computers can help.

As science researchers and professors, we have had a fairly broad collection of experiences in using computers, from batch-processing and number crunching in large computer systems using FORTRAN and symbolic languages to teaching problem-solving courses for nonscience students using personal computers. While we claim no special computer expertise, we both own computers and are frequently called upon to offer advice to our colleagues who are greater novices than we are. Hence, on the basis of reflections on our experiences and observations of what we have seen other people and institutions do, we have compiled a list of "Do's" and "Don't's" about computer-assisted instruction, software, and hardware.

These are our recommendations.

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Paradigms

You need to seriously reflect on the *paradigm* that you are using when thinking about computer-based education. A computer is not just a complicated hand calculator. With modern applications software, a personal computer can become a learning environment for your students. Be prepared to change your paradigm (Fuller 1978).

Do start with a statement of the educational objectives for what you want to accomplish. Science education, after all, is the main goal of the exercise and this must always come first. Remember, computers will enable your students to do problems that have previously been beyond the scope of your science courses.

Don't be limited in your view of computer uses by what you have done in the past. The distribution of millions of computers has created a software development industry unparalleled in previous computer history. New application software has invented new computer uses available

to nearly any interested person—for example, numerical calculations using spreadsheets, digitized sounds, art and graphics, desktop publishing, and microcomputer-based labs.

Do try to make a list, as exact as possible, of how the computers can best help accomplish your educational objectives. This list will be crucial in helping you match computer hardware/software to your needs. All computer hardware is *not created equal. Some hardware/software systems are better, or more cost effective, at some tasks than others.*

Don't try to substitute computer experiences for hands-on experiences or demonstrations of real events. Computers have their place, but try to remember that science is an explanation of how nature behaves. Science is based on naturally occurring events, not computer results.

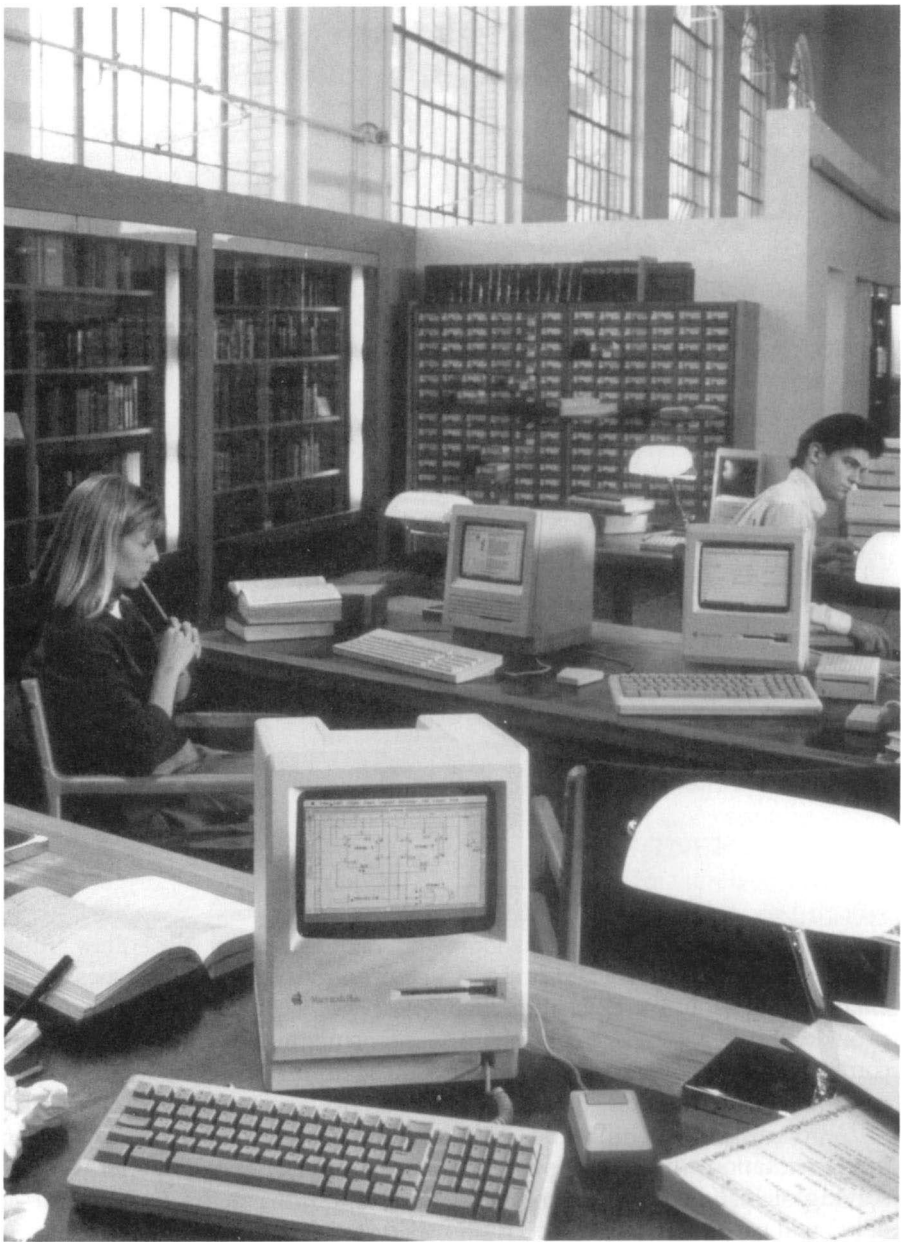
Do explore a variety of ways to use computers in teaching science. There is no one correct way to use computers. There are many ways in which computers can do things that books and lectures and labs cannot do.

Relax: Start Slow

Make sure that your *instructional style* is compatible with the use of computers. If not, then leave them alone, or be prepared to change your style.

Do put your students to work on the computers as soon as possible. Small groups of students can help set up your systems and your software and serve as tutors for others. These more experienced users can help you run tutorial sessions for other people.

Don't try to keep ahead of your better students. Computer systems and software are good areas in which to let students see that you don't know everything. What you do know is how to effectively learn new things and to help other people learn new things. Computers are one aspect of the world in which you can clearly demonstrate that the proper function of a professor is *not* to provide the final answer to every question, but to ask questions that can point students in directions to seek answers.



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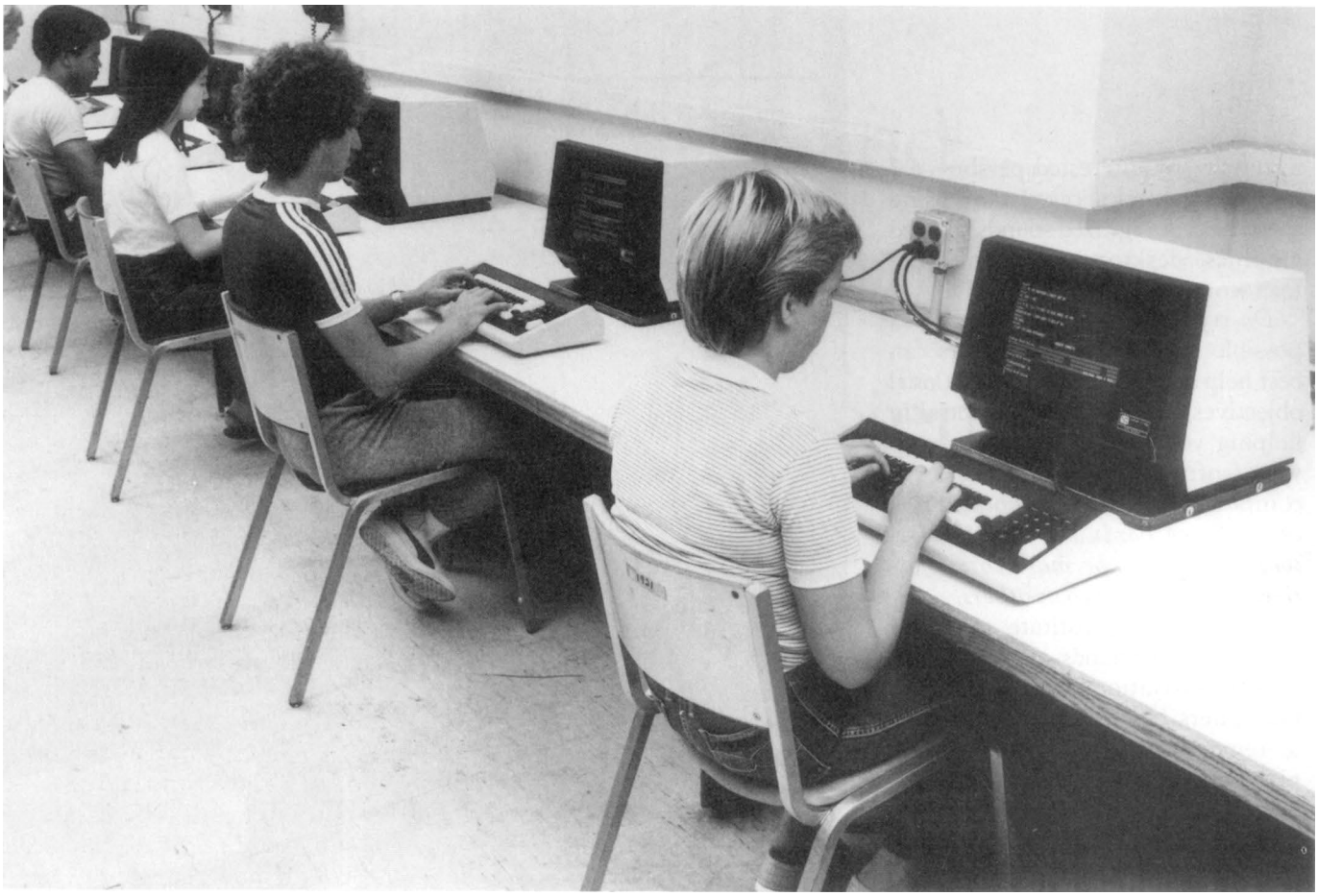
Do be aware that many students still have a high level of computer anxiety. This can be alleviated somewhat by using "user-friendly" software and help sessions.

Don't overlook the natural appeal that computers have for some students. Some students will thrive on using the computer. This is both good and bad. Always encourage students to remain focused on science.

Do include some writing in every computer assignment. We have found that only requiring the students to hand in a page full of numbers or a graph does not offer the kinds of learning experiences we want for our students. Use the word-processing power of the computer to help your students learn to interpret and explain their work with words. Students can be asked to provide some written information about nearly any kind of computer assignment from drill and practice to simulations.

Don't neglect the value of drill and practice work for some students. Computer use should allow you to provide a greater variety of ways of learning science than you provide



without computers. Drill and practice exercises are about the easiest ones to provide, and many students find them comforting. Just don't limit your computer use to this process.

Do discuss algorithms and their implementation when germane to the solving of real-world problems. Students will gain a greater appreciation of the limitations of science when grappling with data.

Don't spend a lot of class time teaching key strokes or mouse movements. Concentrate on science-related tasks. Perhaps give just a short introduction or handout to get the students started. Let them consult user manuals and software books to learn more advanced features.

Don't teach computer programming. The focus must remain on science. Provide guidance and resources, but keep the students working on real science problems.

Don't start your use of computers in science instruction by writing a number of your own programs. Try a few programs from colleagues or start with a few commercial programs and experiment with ways to incorporate those into the way you teach. Numerical calculations and graphing are two excellent ways to introduce computers to your science students.

Computer Ethics

Computer hardware and software are two more areas where you can serve as an *ethical role model* for your students. Remember, education is more than a bunch of facts, and the most important influence you may have upon your students can be in teaching them professional values.

Do set a high standard of ethical use of computer software. Buy copies for all of your computers. Let your students know you stand behind the present copyright laws on computer software.

Don't encourage software piracy. Don't allow pirated copies of software to be run on your systems.

The era of the personal computer has brought us a flood of computer *software.* Now, not only do you have to deal with new editions of textbooks, but also you have to decide what software to use and when.

Do buy the most powerful software you can afford for the tasks that you want done. The many hours you use the software will more than compensate for the differences in initial costs.

Don't overlook low cost specialty software. Sometimes the software that only does *one thing well* is more effective than an expensive general purpose package that does several things, but not as well.

Do keep your system and your software up to date. Usually it is cost effective to pay for the latest *well-tested* upgrades of your operating system and your software as long as it is compatible with the hardware that you have. But it is not wise to upgrade software you no longer use frequently.

Don't spend lots of money on features that you will seldom use. Put

your money where your need is.

Do plan to spend some money on software manuals and related books. Many of the common software packages have third party books that are better than the manuals that come with the software. You can help your students learn how to use software by making some of those books available for their use.

Hardware

The computer revolution is so called because the world seems to have become flooded by all kinds and sorts of computer *hardware.* How can you ever keep up?

Do try to catch the front of the swelling wave of the most powerful hardware you can afford when you make your purchases. As time passes you will want to do more and more with your computers. You will need more random access memory (RAM), more storage, more speed, more of everything. You ought to overbuy your present needs. Remember, a computer generation lasts about two and one-half years now, so your hardware will get old very, very rapidly. If you buy last year's systems today, they will be old before you learn to use them. In 1986 the future belonged to the IBM machines and their clones. Today many prefer the Macintosh family and the 386 family. Tomorrow it may be the NeXT machines or a Sun™ micro system. Note, however, that you do not want to buy tomorrow's system today. Usually, you do not want your students to be guinea pigs.

Don't restrict your purchases to hardware that is compatible with what you already have. We live in a vast world of a variety of computers and that seems likely to continue for many years. It is hopeless to try to protect yourself from having to learn more than one operating system or from having to expose your students to more than one set of hardware. You must become prepared to see your latest hot hardware become old hat in just a few years.

A computer generation lasts about two years—catch the beginning of the wave when purchasing hardware.

Do try to match the capabilities of the hardware you buy with the tasks you wish to accomplish. This is easier to say than to do, but you will need to read about computers and talk to others with uses similar to yours in order to decide what hardware is best for you.

Don't nit-pick about your hardware. No computer system can do everything well, so be prepared to overlook some weaknesses in order to match the capabilities of the system with your high-priority tasks.

Do allow the hardware and software that are supported by your institution to play a role in your decisions about what to buy and use. It is easier to use and maintain computer systems that are being used by other people in your school or on your campus. This ought not to be your major concern, but you should not ignore local wisdom either. Having local experts available as well as holding training sessions for new users can be an important aspect of computer use.

Don't spend a lot of time trying to get your computer system to do those things that it does not do well. Sometimes faculty members get caught up in one faulty aspect of computers and neglect others that computers do well. At least encourage your students to do word processing and simple numerical analyses in addition to real-time simulations of physical phenomena.

In Sum

We can't stop without a few summary comments.

Do worry about access. *Access* to the computers is everything. If students do not have computers within easy reach at convenient times for them—This usually means nighttime access!—then only the most ardent of students will take full advantage of them.

Do keep current with the trends on computers in education. For example, consult Fuller 1986. Your time is better spent than in reinventing the wheel. Attending conferences and reading the literature are the ways to accomplish this.

Do start to think of your computers as a possible gateway to an international network of computer users. The national BITNET and other network services make electronic communication more and more attractive. For starters, you can join a users group, such as the Physics Educators Macintosh Users Group. (Send your name and address to R.G.F. by conventional or computer mail.)

Don't be afraid to make mistakes. The use of any tool in teaching is a learning process—as is teaching itself. Perfection is not immediately attainable.

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There you have our recommendations. What do you think? We welcome your comments and suggestions. Correspond through our electronic mailing system: Glenn [Sowell@ HOSS.UNL.EDU.] and Robert [PHYS058@ UNLCDC2. BITNET]. □

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