Lower-Order and Higher-Order Skills


I begin one of my favorite workshop activities discussing the idea of effective procedure—that is, the types of procedures that computers can carry out—and how this relates to problem solving. I then ask the workshop participants to identify disciplines that seem to have a relatively high or relatively low concentration of effective procedures. Mathematics is usually the unanimous choice for the discipline with the highest concentration of effective procedures, although the physical sciences sometimes run a close second.

The fun begins as workshop participants start to name disciplines with relatively low concentrations of effective procedures. Art is frequently mentioned, but I then suggest that the graphical or commercial arts seem to make major use of computers. Sometimes the social sciences are mentioned. But by then some workshop participant will give a solid argument that the organization, storage, retrieval, and presentation of information is greatly helped by computers.

Eventually a pattern emerges. Each discipline has some parts where computers are very useful and other parts where computers are of modest or no use. Even math fits this pattern. Math is viewed by many mathematicians as an art form, as a field requiring a great deal of creativity, and as a field where computers are mostly useful in carrying out routine computational or manipulative tasks.

**Skills for Problem Solving**

Within each academic discipline there is a continuum of knowledge and skills. Bloom’s taxonomy is a division of this continuum into (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis and (6) evaluation. Many educators refer to the first three as lower-order skills and the latter three as higher-order skills.

It seems evident that problem solving requires both lower-order and higher-order skills. For example, suppose one is faced by the problem of writing a descriptive narrative using pencil and paper. Then spelling, grammar, and penmanship are lower-order skills that will enter into the final product. But no matter how well these lower-order skills are used, the writing may turn out to be very poor. Good writing has style; it has appropriate and rich use of vocabulary; it communicates clearly. The production of good writing requires use of such higher-order skills as information retrieval, organization, drawing on a rich vocabulary, understanding the intended audience and the purpose of the writing, revision, and so on.

The problems in each academic discipline can be analyzed in this same way. In arithmetic, one has many lower-order skills such as writing the numerals, counting, and performing the four basic arithmetic operations. One has higher-order skills such as representing real-world problems as arithmetic computations, applying problem-solving techniques such as breaking a big problem into more manageable pieces, estimating, detecting computational errors, and interpreting computational results in light of a real-world problem that one is working to solve.
Educators have long understood the dichotomy of lower-order versus higher-order skills, and each curriculum reflects a balance between them. But even within the school systems of a single state, there may be major differences in emphasis on higher-order and lower-order skills. In some schools the balance is heavily weighted toward lower-order skills (rote memorization is stressed) while in other schools there is more emphasis on analysis, synthesis, and evaluation.

The balance between lower-order and higher-order skills can change in an educational system over a period of years. Education in the United States began a “back-to-basics” movement more than 15 years ago. This movement included increased emphasis not only on reading, writing, and arithmetic, but also on the basic skills in these and other disciplines. Now many educational leaders in the United States are arguing that the back-to-basics movement was a mistake and that we should be placing much greater emphasis on higher-order skills.

One argument for increased emphasis on higher-order skills is based on an examination of the steady decline in college entrance exam scores that extended over many years and just recently appears to have bottomed out. An analysis of such test scores indicates that the basic skills component of these scores actually increased. It was the higher-order skills scores that declined drastically and dragged down the total scores.

A second argument should be made by computer education leaders. Most of the effective procedures that computers can carry out fall in the lower-order skills area. For example, in writing, one can have a word processor (as contrasted with penmanship) and one can have both spelling and grammar checkers. In arithmetic one can have a calculator. The argument is that appropriate use of computers can be a partial substitute for some lower-order skills.

To me the argument seems clear. A good education must be balanced between lower-order and higher-order skills. Computers have a greater impact on lower-order skills than on higher-order skills. For example, in a wide variety of disciplines, computers make it more appropriate to retrieve information than to memorize it. Computers can carry out routine manipulative tasks that require substantial schooling for humans to learn to perform. Thus, some of the time currently being spent on lower-order skills can be replaced by a combination of appropriate use of computers and more time spent on higher-order skills.

In several recent workshops, I have raised the idea that we might replace much of the cursive writing penmanship curriculum by keyboarding. (This idea was suggested to me by my colleague Keith Wetzel.) While there is an initial round of outright shock and laughter, the majority of participants in my workshops support such an idea! The next time you want to provoke an argument with traditional educators, you might suggest that penmanship is of rapidly declining importance. When the argument begins to wane, suggest that everyday voice input to computers is now visible on the horizon.

There are many things that people can do better than computers—especially if they have an education that emphasizes higher-order knowledge and skills. An appropriate education for the Information Age must take into consideration the capabilities of computers. The education must prepare people to work with computers, rather than compete with such machines. All computer educators should be encouraging a greater emphasis on higher-order skills.