Computers and Mathematics Education


Calculators and computers are having a significant impact on math education. However, I feel that the impact is smaller than it should be. Math educators need to "think bigger" as they plan for the effective use of calculator and computer technology.

The Essence of Math Education

Mathematics provides vocabulary and notation to represent a wide range of problems. The cumulative mathematical knowledge on how to actually solve math problems is immense. Thus, the essence of math education is to:

1. Help students learn to represent (model, pose) problems using the vocabulary and notation of mathematics.
2. Help students learn how to effectively build on the collected knowledge of the field of mathematics, for example, in solving math problems.

People can learn a great deal of useful mathematics with a minimum of formal (in school) instruction. However, formal instruction and disciplined study is needed for most students to make significant progress in working with fractions, algebra, geometry, calculus, statistics, and so on. Math is considered to be such an important subject that most students are required to study this field for 10 or 11 years in the precollege curriculum.

Roles of Computer Technology

Computer technology plays two major roles in math education. First, it can aid in the delivery of instruction. Computer-assisted instruction in mathematics includes drill and practice, tutorials, simulations, and microworlds. All these forms of instruction can help students learn faster and better.

Second, computer technology can facilitate change in what students learn. For example, the proliferation of hand-held calculators has lead to the gradual disappearance of bv-hand calculation of square roots from the curriculum.

Computer-Assisted Instruction

There has been a tremendous amount of research about CAI over the past 40 years. There have been dozens of metastudies—studies of studies. In brief summary, CAI works. On average, students learn quite a bit faster. They learn equally well or better, compared to "conventional" instructional methods.

There is a huge and ever increasing amount of mathematics CAI software available commercially. There are many different pieces of software that facilitate exploratory activities in graphing, geometry, algebra, and statistics. Many of these pieces of software might be classified as edutainment—certainly they tend to hold students' interest.
I wonder why all students do not have access to such materials at all times when they are learning mathematics.

**Computer Technology and Mathematics Content**

Our mathematics education system has gradually dropped the by-hand calculation of square roots as well as interpolation in tables. It has made other modest changes, including an emphasis on the use of hand-held graphing calculators in the upper grades of high school and in college.

The potential of computer-as-tool is tremendous. The following diagram captures the essence of how math is used to solve problems.

The diagram indicates four relatively distinct steps:
1. **Math modeling.** Representing a problem using the vocabulary and notation of mathematics.
2. **Solving a "pure" math problem**
3. **Math un-modeling.** Translating the mathematical conclusion-' back into a statement about the original problem,
4. **Interpretation of the results.** It may be that the original problem has been solved, or it may be necessary to re-pose the problem and start over.

The math teachers I talk to estimate that about 80 percent of mathematics education time is spent on step 2. This may be an overestimation, because a huge amount of math education time is spent on learning the vocabulary and notation of mathematics. However, it is clear that our mathematics education system places far more emphasis on step 2 than it does on the other three steps.

The greatest strength of calculators and computers in mathematics is their ability to do step 2. An inexpensive calculator can calculate square roots. A calculator costing less than $100 can graph, solve equations, and provide the user with useful help in working with a hundred or more built-in mathematical functions.

The computer-based aids to solving math problems can solve the full range of problems that students typically study up through the first couple of years of college mathematics.
Why does our mathematics education system spend so much of its instructional effort teaching students by-hand methods of doing what computers can do? Why aren't all students provided with the powerful computer-based mathematical tools?

**Final Remarks**

My discussion seems to give equal weight to CAI and the computer-as-tool. However, I believe there is at least an order of magnitude difference in the potential of these two approaches to improving mathematics education. The best of math-oriented CAI may well help students learn 30 percent to 50 percent faster. The best of the computer tools may reduce the time unnecessarily spent on by-hand methods by a factor or 10 or more.

The National Council of Teachers of Mathematics has made some progress in supporting the use of calculators and computers. But I believe that the NCTM is thinking too small. Progress toward achieving the full potential of computer technology in mathematics education is proceeding at an agonizingly slow pace.

[Send your questions for this column to Learning and Leading With Technology, ISTE, 1787 Agate Street, Eugene, OR 97403-1923: fax 503/346-5890; e-mail isfe@oregon.noregon.edu. You can e-mail Dr. Moursund directly at moursund@oregon.uoregon.edu.]