The Bank Street SOFTWARE LETTER

a friendly guide
for parents and others

Learning to Think Mathematically

Walk into any classroom or lab with computers, and you are likely to see students working with mathematics software. And more than any other type of math program, you will see drill-and-practice routines. These present students with problem after problem, grilling them for the "basic" math facts of arithmetic (such as the multiplication table) or algebra (such as moving quantities across the equals sign). Drill-and-practice programs basically mechanize the familiar flash cards we all used in first grade.

Not only do drill-and-practice programs turn the computer into an over-qualified babysitter, but most of them leave out fundamental aspects of mathematics learning. Even though math facts are important, the central goal of mathematics education should be to support students in learning to *think mathematically*. The National Council for Teachers in Mathematics suggests that what is "basic" includes being able to call up knowledge and strategies flexibly and efficiently to *solve new problems*.

A Shift in Priorities

In the past several decades, research has transformed how we think about learning mathematics. In the past, the teacher's focus was primarily on getting children to give the "right answers" to mathematical problems. We now know that to think flexibly for problem solving in mathematics, students need to be taught not only the answer, or product, but the thinking, or *process* involved. This thinking process involves many component skills.

The mathematician George Polya divided the problem-solving process into four major phases: defining and understand-

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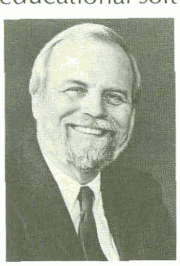
R3's CORNER

In the last software letter, I described the major categories of educational software and suggested criteria for evaluating software within each category. Specific evaluation criteria are indeed helpful. But can we also define general guidelines that apply to all educational software? I think so.



In many ways, choosing software for kids is like choosing a good book for them to read. The first quality that parents should look for in choosing any software is *ease of use*. The way the child communicates with the program (often called the user-interface), should be essentially transparent so that the child can use the program very rapidly and not spend

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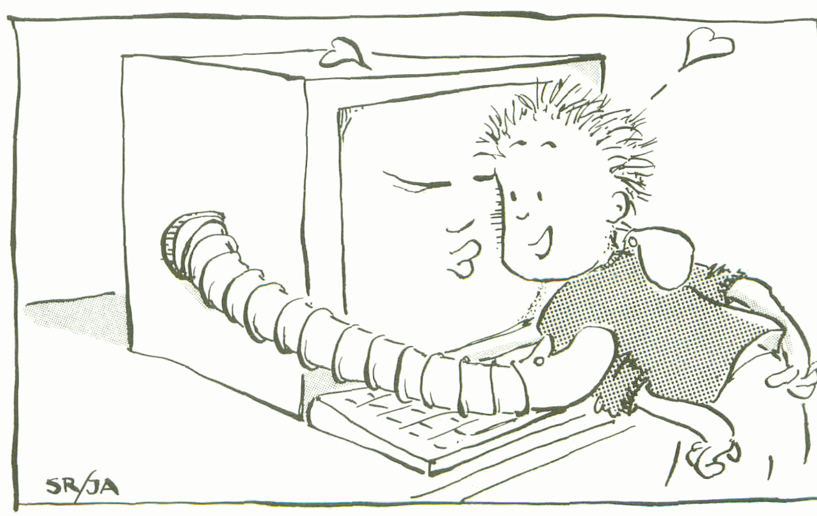

Now that's what I call user friendly!

ing the problem, making a plan for how to solve it, trying out the plan or alternative plans until some success is met, and consolidating what one has learned so that this problem-solving experience may be applied to similar problems.

We can see from this list that the "right answer" is only a small part of a problem-solving approach. Getting there is much more than half the fun. Just as most of us write and revise many times to arrive at a good essay, so we may need to approach an equation many different ways to arrive at a solution.

"It combines mathematical principles with linguistics and child development theory and applies them to Candyland."

Problem-Solving in the Real World

Of course, even drill-and-practice software that drills students on single-digit subtraction presents "problems" that the student must solve. But the problem-solving involved in most of mathematics is much more interesting and complex.

In the world outside school, problems do not come defined in electronic workbooks, and there are no answer sheets to turn to. Say an ecologist needs to know the effect of a larger beaver population on the deer that populate a certain ecosystem, or a city planner is predicting the change in the flow of traffic a proposed new building would cause: most likely no one has run across exactly these problems before. Each of these people must define the problem and figure out ways to attack it. And working on the problem, the person may come to realize that a new variable must be added to the problem definition. Psychologists have discovered that solving a problem is a back-and-forth (recursive) process, not a linear one. What students need to know is not just answers, but how to define and solve problems that require this recursive mathematical thinking.

Computers in Math

The recent shift in the focus of math education can also be attributed to the availability of computers to aid mathematical thinking. Computer programs (such as "TK! Solver," an equation solver) can free the ecologist and the city planner to define their problems and set up equations, rather than get bogged down in the tedious calculations necessary to work through those equations. With some creative work on the teacher's part, these same programs can free up the student as well.

This problem-solving approach to learning math focuses on *projects* rather than exercises. It does away with the drudgery of remembering and practicing mathematical mechanics, like long division (once the principle of division is thoroughly understood). And it brings math back from the textbook into the realm of practical reality, where the motivations for mathematical thinking arose in the first place. In this way, math can become for the student "my math" rather than someone else's, with unknown origins and purposes.

Motivating Math

Programs like "TK! Solver" are designed for professionals as well as students. But how can good math software be specifically tailored for students?

One way is to present a situation in which the math to be learned is necessary to deal effectively with the problem. For example, in "Rescue Mission" (Holt, Rinehart and Winston) students must navigate a boat in order to save a whale trapped in a fishing net. Various arithmetical and geometrical skills are needed to use the naval instruments necessary for navigation. Similarly, Sunburst has created simulation programs in which students use math skills as aids to planning and problem-solving in real-world situations, like running a business ("The Whatsit Corporaiton") and trip planning, construction, and best-buy shopping ("Survival Math"). Programs like these can *motivate* mathematical thinking in otherwise ambivalent students.

Another way to motivate mathematical thinking is to provide a social context for math problem solving. Computer programs can help create an environment in which students can discuss, reflect upon, and collaborate on the math necessary to solve a problem. The "Bank Street Laboratory" (Holt, Rinehart and Winston), for example, is composed of hardware devices which plug into the computer and can be used to measure and graph changes in light, temperature, and sound over time. Supplementary teacher materials suggest activities where students work together as a team to apply mathematical thinking in making scientific discoveries.

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Mathematically . . .

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Computer-Aided Intuition

A second function of educational software is to help students understand and use the different mental activities involved in math thinking. Using "The Geometric Supposer" (Sunburst), for example, students make conjectures about different mathematical objects, like medians, angles, and bisectors, in geometrical constructions. In this way students can discover theorems on their own. The program is an electronic straight-edge and compass. It comes with "building" tools for defining and labeling construction parts (like the side of a triangle or an angle), and measurement tools for assessing length of lines and degrees of angles. Students find this program an exciting entry into empirical geometry (induction), and it can be used to complement classroom work on proofs (deduction).

A second important mental activity central to mathematical thinking is understanding the *mapping relations* between different ways of representing a mathematical problem. "Green Globs" (in *Graphing Equations* by Conduit) and "Algebra Arcade" (Brooks-Cole) do this for algebraic equations and graphs. A random distribution of little figures appears on a Cartesian *x-y* coordinate grid. Students must create algebraic equations, which the computer graphs, to hit the figures and score points. Students become facile at knowing how changes in the values of equations, such as adding constants or changing factors (*x* to *3x*, for example), correspond to changes in the shape of the graph. They discover equations for ellipses, lines, hyperbolas, and parabolas.

These are exciting times for learning and teaching math. The rigid attitude that the mind is a muscle to be exercised through mechanical repetition is giving way to a richer view of the creative, exploring mind that computer tools can aid and enhance. By infusing life into the learning tools for mathematics, children can realize how mathematics offers personal power. In this way, a child learning mathematics is learning but one more way to think, and to fully develop his or her personal voice in the world.

— Roy D. Pea

Roy Pea is Associate Director and senior research scientist with the Bank Street Center for Children and Technology.

R3's Corner . . .

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too much time trying to figure out how to make it work.

This is analogous to choosing the right reading level. As a parent, you choose books that you know your child can read with a minimum of frustration. If the reading level is too high, the child will never be able to get to the content.

The second quality to look for is *depth.* If a child uses the program once or a few times, does she lose interest? This is often true of game software. You may be able to shoot down ten fighters or one hundred fighters, but if all you can do is shoot down fighters, the child will quickly lose interest.

A program with some degree of depth or complexity, however, invites the child to return time and again, as might a good book. And as her skill improves, she'll be able to take more advantage of what the program offers. You'll find that this is particularly true of some of the better simulations and adventure games.

Good software doesn't "talk down" to kids or trivialize what they're doing. It has a direct link to an activity that's valuable in the adult world. A good music processor, for example, lets the child compose music by ear, then displays the notes, prints them on paper and plays the song in different ways according to the child's direction. The product that the child creates is musically correct, and the activity has a direct link to a very important adult creative activity.

Of course, there are some questions that apply to computer functions, and have no parallel in the world of books. For example: Can the child print out what she's done? Does the software make good use of things like color and sound where they are appropriate? Is the program interactive? (Can the child exercise discretion and judgment?)

One way to find these things out is to ask a knowledgeable person. If there's a teacher or parent at school who has a reputation for knowing about software, then it's worth a call. Books and magazines about computers are also available. Our own *Bank Street Family Computer Book* was, in part, an attempt to fill this knowledge gap. Use these sources to find out more specifics about good software and which publishers can be counted on to produce high-quality materials. Then you can decide which of the good software is right for your child.

— Richard R. Ruopp
President of
Bank Street College

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Computer Maintenance Myths

PART II

In the last issue we shattered myths that have evolved around the maintenance of computer hardware. This month we'll tackle another class of computer myths — those surrounding the care of disks and disk drives.

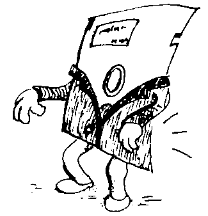
One superstition making the rounds is that if you're going to throw a disk down on a table top, without its protective envelope, it's all right as along as the label is facing up, because the actual data won't come into contact with the dust, spilled soda, and sharp objects cluttering up your computer table. In fact, on single-sided disks the data is all stored on the "bottom" side (the side without the label). It's not a good idea to throw your disks around at all, especially without their little jackets. But if you must abuse them, remember that it is their backsides that are most sensitive.

Another debate about disks is whether they can be harmed by taking them through airport entrances. In fact, there has been no accepted wisdom on this, and it took many phone calls to get some. The answer is, well, yes and no. Two kinds of machines are used at airport gate entrances: X-ray machines that check luggage, and metal detectors that check people. X-rays will not harm disks; the microwaves used by metal detectors will. Information on the disk is stored magnetically, and microwaves can change or destroy some of the magnetic structure. That is why you are often warned to keep disks away from magnets, library security systems, televisions, telephones, and other electrical appliances.

Since most airports have X-ray machines right next to the metal detectors in the areas where they check passengers and carry-on luggage, it is probably still not safe to let your disks go through the X-ray machine. It is better to have the guard hand-check your disks and walk them around both machines, a few feet away.

If you have disks in a suitcase you're not carrying on board with you, then they will only be X-rayed, and are safe — except that temperatures in the storage compartments of airplanes can get very low. Acceptable temperatures for disks are 50 to 125 degrees Fahrenheit. Blank disks, which have not been formatted and contain no data or information, can be X-rayed or microwaved, since there is nothing to be lost.

A ruling that often gets handed down from the computer gurus is that disk drive doors should be left closed when not in use. This advice is not completely unfounded, since closing the door prevents dust from getting into the drive. But leaving it closed also applies constant pressure to the read/write head of the drive and to the spindle that keeps a disk in place during use, and this pressure could gradually cause the disk drive to become unaligned. So all other things being equal, it's best to leave the door open. If you are storing the computer for a long time, over the summer, for example, cover the computer system with a cloth to protect it from dust.

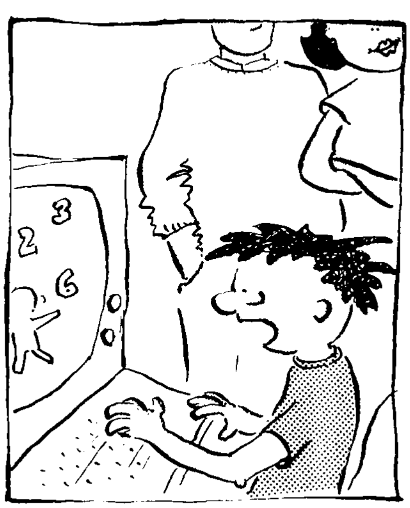


The disk drive is the part of your computer that is most likely to need repair. When disks will not boot, or when they run erratically, it is often because the read/write head in the disk drive is out of alignment or needs to be cleaned, or the disk drive is not timed properly. All of these repairs can be taken care of at home, but specific procedures vary among different kinds of computers. Check with your local computer users' group or relevant computer magazines.

Remember that your home computer is a household appliance, and basically a reliable machine which, with proper care, can last many years. You can apply the same common sense principles to its maintenance that you can to your car, bike, or home stereo.

— Kathy Rehfield

Kathy Rehfield is a Field Advisor for Computer Outreach Services at Bank Street College of Education.



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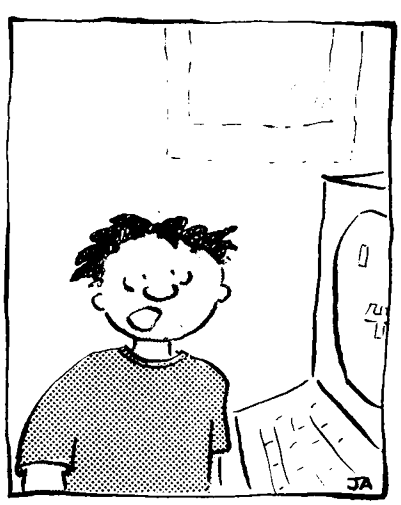

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