who were illiterate or humanists who were innumerate.")

But most science-education analysts don't think course offerings explain the whole disparity in scores. Many point to other potential cofactors described in the U.S. study involving 6,156 teachers, authored by Iris Weiss, formerly with Research Triangle Institute in Research Triangle Park, N.C. (and now the head of Horizon Research Inc., a consulting firm in Chapel Hill, N.C.). Looking at how teacher training and science/math teaching have changed over the past 10 years, Weiss found several disturbing trends.

Chief among them, she believes, is that teachers are spending more time lecturing their classes and less time on hands-on projects. "This is exactly contrary to what scientists and science educators recommend," she told SCIENCE NEWS. In 1977, she points out, on any given day roughly 60 percent of classes would involve laboratory work and about 70 percent would include lectures. Now only about 40 percent are doing hands-on work on any given day, while some 80 percent include lectures. She found that elementary grades are more likely to include hands-on training and less likely to involve lectures than either junior high or high school classes.

Even more important, Weiss believes, is the actual amount of time spent on hands-on work. In kindergarten through sixth grade, a science class spends just about as much time (28 percent) on hands-on activity as on lectures (25 percent). But by junior high, an average of 11 percent more classroom time is devoted to lecture than to hands-on activities. By high school, lecturing accounts for 43 percent of the class time – more than twice the time devoted to laboratory studies.

Weiss was also "astonished" at the low classroom use of computers. While virtually every school in the study had computers, she says, only 8 to 15 percent of science classes and 19 to 23 percent of math classes studied had used them in the week prior to the survey. Moreover, of the classes that had used them, most had logged in a total of only 15 minutes or less during that week.

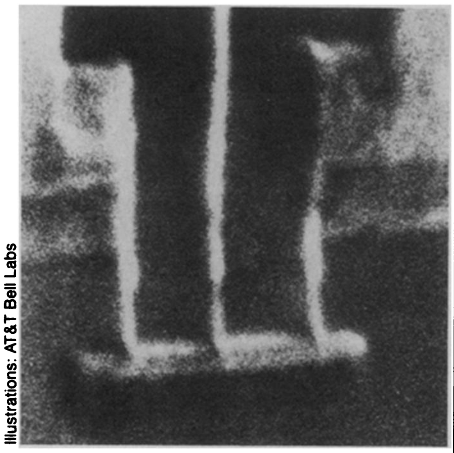
Finally, her data showed that unexpectedly large proportions of high school science and math teachers have an actual degree in science or math (76 and 52 percent respectively) – not just science or math education. However, a third of the chemistry classes and half of the physics classes were taught by individuals who had studied a different field – usually biology. Weiss considers this quite troubling. "Teachers are being trained as if they're only going to teach one subject," she says. Perhaps, she suggests, they should sacrifice some depth of training for some background in a second scientific field.

While conceding that most analysts recommend focusing initial corrective action on the youngest students in the U.S. educational system, F. James Rutherford, chief education officer for the Washington, D.C.-based American Association for the Advancement of Science, believes this is not the way to address such a systemic problem. "I won't be happy," he says, "until we're attacking the problem on all fronts." – *J. Raloff*

Transistor sensitive to one electron

In this day of transistors doing prodigious things, who remembers vacuum tubes? Electronic circuit elements are getting finer and finer and more and more precise. Now there is a transistor so precise that it will respond to a voltage change equivalent to a single electron.

According to a statement by AT&T Bell Labs in Murray Hill, N.J., where Ted Fulton and Gerry Dolan developed the device, the best previous miniaturized field-effect transistors (FETs) require thousands of electrons to elicit the same response. The one-electron transistors, in Bell Labs' estimation, "show potential to change the way we think about a future generation of integrated circuits, because they use infinitesimal amounts of power and space; have an intrinsic speed of less than a picosecond; . . . and use the smallest possible amount of charge transfer."

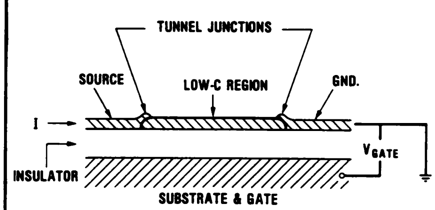


Illustrations: AT&T Bell Labs

An electron micrograph magnifies the new "one-electron" transistor 100,000 times. Electrodes run upward from either end, and a probe for test measurements comes down the middle.

Transistors most often work as switches. An input current either comes out through the output terminal or not, depending on the state of a part of the transistor called the gate. These new transistors work best when made of superconducting metals – the old-fashioned, very low-temperature kind, not the modern high-temperature ones. The devices consist of two tunnel junctions separated by an "island" of metal only a few hundred atoms across. In a tunnel junction, two superconducting electrodes are separated by an insulating barrier only a few atoms thick, and current passes through the junction by the phenomenon known as quantum mechanical tunneling. The junctions and the island between them lie on an insulator, above a conducting substrate. A voltage – that is, an electric field – applied across this insulator forms the gate and controls whether or not current flows between the two junctions.

In the new devices, an electric field equivalent to a single electron will turn the current on or off. "If you charge the gate capacitance up to the equivalent of a single electron, 10^{-16} of a farad," says Fulton, "the device goes through its entire cycle." That is, it goes from full current to no current. "It's really cyclic in one electron." Furthermore, the cycle can be subdivided, so that the transistor is sensitive to changes as small as the equivalent of 1 percent of an electron. This leads to the suggestion of an early possible application as electrometers for measuring extremely minute electric fields.



Schematic drawing of the "one-electron" transistor shows current – designated by I – entering at "source." It will exit at "GND" if the voltage (V) across the gate lets it.

New fabrication techniques developed by Dolan allow the microscopic transistors to be made less than one-twentieth of a micron across. The researchers use electron-beam lithography to make a pattern on an organic film layer. Then they deposit the electrodes and the barrier. Fulton and Greg Blonder, who heads the Bell Labs department where the work was done, stress that only the old-fashioned metal superconductors, which require refrigeration by liquid helium, can be used. Nobody has yet succeeded in making tunnel junctions with the new high-temperature superconductors, they say, and furthermore, the new materials do not have the stability and uniformity of properties required for this application.

At the moment the new devices are experimental, although there is a potential for applying them in computer circuitry. However, says Blonder, "You will be a lot older before you see it."

– *D.E. Thomsen*