Looking Forward and Backward


June—the end of another school year. It's a good time for reflecting about what has been and what could be. I hope that you are saying; "This past year has been good, and I expect next year to be even better."

But why restrict yourself to just last year and next year? Why not think back to when you first got started with computers, and then an equal distance into the future?

For me this is a particularly interesting exercise because I got started with computers nearly 30 years ago. Thirty years ago I was just graduating from the University of Oregon with a bachelor's degree in mathematics and quite a bit of coursework in physics and chemistry. I had heard about computers—mainly in science fiction books—and was quite interested in learning about them. But the University of Oregon didn't yet have a computer.

After six months in the army and a few months of graduate work at the University of Oregon, I headed off to the University of Wisconsin in Madison. The University of Wisconsin had a computer, an IBM 650, that was used for research and instruction. It was a first generation machine, meaning that it contained many thousands of vacuum tubes. It could perform 2,000 additions or 100 multiplications per second. A 1958 textbook written for this machine talked about how difficult it was to comprehend such "lightning" speed. When properly programmed in machine language, the IBM 650 could calculate a square root to full machine accuracy in about a sixth of a second. That was certainly impressive, as anyone who has done such a computation by hand can testify. The IBM 650 was representative of middle-priced computers of 30 years ago.

There has been quite a bit of progress since then. For example, recently I purchased a solar-battery-powered, six-function calculator with four-key memory. This $2.99 calculator weighs less than three ounces and its built-in square root function is just a little slower than the machine language program for the IBM 650.

A recent issue of Business Week discussed the computer industry and its expected production figures for 1988. The total amount of compute power expected to be manufactured this year is awesome. In some sense it is more than equivalent to an IBM 650 for every person on earth. That is, if one adds up the total number of operations per second that all of the computers produced in 1988 will be able to perform, and divides by the earth's population, the result is a number quite a bit larger than the speed of an IBM 650 in operations per second.

Of course, this doesn't mean the computer industry is capable of manufacturing five billion computers during the current year. But it does suggest that things have changed quite a bit during the past 30 years. In the United States, for example, about one-fourth of the work force now regularly uses computers. Many millions of people own computers that are far more powerful than an IBM 650.

One way to measure progress in the computer industry is by use of the price-to-performance ratio. Over the past 30 years the price-to-performance ratio has decreased by a factor of approximately 10,000. Some of this improvement has gone into making computers cheaper, while the rest has gone into making computers of a given price much faster. For example, a mid-
range computer might be 10 times cheaper and 1,000 times faster than a mid-range machine 30 years ago.

Now, let's look to the future. Careful studies suggest that the price to performance ratio of computers is declining by a factor of 10 every seven years. Moreover, we have good reason to believe that this progress will continue for another 14 years. Take a look at how much compute power you can get for $1,500 right now. Fourteen years from now you can expect to buy a hundred times as much compute power for the same price (in 1988 dollars).

Such exponential improvement cannot continue indefinitely. Thus, it isn't clear how much additional hardware progress we can expect as we look still further into the future. Let's pick a conservative estimate and assume that 30 years from now the price-to-performance ratio of computers will only be about 1,000 times less than the current ratio. Thirty years from now today's first grade students will be about 36 years old. Many will be well established in their career and family goals. And most will routinely use computers that are a hundred to a thousand times as powerful as today's $1,500 microcomputers!

What does this mean to our educational system? To me it suggests that the future of computers in education is very bright. It is true that most of us have to work with current shortages of computer hardware and software. It is true that most teachers don't know how to make effective use of computers in schools or how to integrate tool use of computers into their curricula. But that is changing, and such progress is cumulative. In many schools we now have achieved the critical mass stage in terms of amounts of hardware and software, numbers of teachers using computers, and numbers of students using computers. Quite a few students are growing up in a computer-rich environment.

Over the next few years, most of us will continue to feel quite frustrated by the relatively slow progress that computers seem to be making in education. But the progress has actually been quite rapid relative to other historical changes in education, and there are very strong pressures from outside of education that will soon be dominant forces in many schools. In the United States about 15 million homes are already equipped with general-purpose microcomputers. In many schools half or more of the students already have easy access to computers at home. In the next few years we will see a substantial decrease in the cost of laptop microcomputers. We will see many millions of parents providing such computers for their children. My prediction is that this rapid increase in home-provided computers will contribute substantially to the future of computers in education.

Summer vacation is a great change of pace. It is a time for recharging your personal batteries and getting ready for the next year. I hope you are able to spend quite a bit of time playing with computers—messing around with old and new pieces of software, and enjoying yourself. I'm looking forward to seeing you again next fall.