I thought that you would be interested in the attached paper by Robert Gillespie. He is a member of the Stanford President’s Advisory Committee on Computing and Computer Science.
FILLING THE GAP BETWEEN HIGHER EDUCATION COMPUTING RESOURCES AND NATIONAL NEEDS

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Filling the Gap Between Higher Education Computing Resources and National Needs

PROBLEM
There is a large gap in higher education between the computing needs of faculty and students and the resources available. More computing courses are needed for students in all fields, which in turn, mandates an increase in resources—computers, access, and faculty. Recent articles in the Wall Street Journal [January 14, 1983] and the Washington Post [December 14, 1982] illustrate that U.S. colleges and universities cannot accommodate the masses of students—not just in computer science and engineering—who want to learn to use computers.

While large sums are now spent on computing in higher education—over $1.3 billion per year—over half the expenditures are for administration, not education and research. This figure is less than three percent of the total funds now being spent for higher education, providing less than five hours of computer access per student per year. Yet 20 to 25 hours per student per year are required to satisfy course demands. Leading edge institutions such as Carnegie-Mellon and Dartmouth, are providing between 40-100 hours per student per year. The microcomputer revolution is now entering all schools, from primary grades to college. Significant revamping of existing facilities—networks, telephones, curriculum development, etc.—is required support this growth and change, regardless of who buys the computers, students or schools.
The United States holds a lead in high technology industry and research which is crucial to our trade and defense industries. Studies by industrial groups such as the American Electronics Industry show that our growth in many areas will be limited by our shortage of technically and professionally trained people. Other countries—such as Japan—have realized the critical need for human capital and have been making the necessary educational investments to attain leadership. Our competition with the Japanese in the world market for silicon chips shows how important those investments will be and illustrates the long time frame required to solve the problems.

APPROACH

One way to approach this gap in higher education between student needs and the resources available would be to build on previously successful strategies. The program administered by NSF between 1956 and 1965 successfully met the basic objective of advancing American science by stimulating the introduction of computers into colleges and universities. An investment of $70 million, through grants to 184 institutions, stimulated (through matching) a total investment of over a quarter of a billion dollars, achieving the goal. The requirements of institutional plans for the acquisition, introduction, and use of computers and the requirement for matching funds were the critical factors in the success of this program. That investment was a key element in establishing our current lead in technology.
PROPOSAL

The proposal links a previously successful strategy with new approaches involving appropriate roles for higher education, NSF, and industry.

To address the gap, add funds to the NSF budget to:

1. administer a matching program aimed at expanding access to computers in universities and colleges;
2. develop a process utilizing existing and planned resources for displaying campus needs in terms of students and faculty.
3. provide incentives for industry involvement by considering gifts and other support as part of the matching; and
4. require accountability from universities by reporting on their progress toward closing the gap.

Funds should be on the order of $200 million to ensure a major impact.

ADVANTAGES

The approach:

--- draws on a successful program
--- uses the experience and responsibility for leadership by NSF
--- allows the universities to develop their institution-wide response
--- does not require new legislation
--- addresses long term needs for computer experience

This is an approach that can close the gap and address the "accidental revolution."
Campus Glitch
Universities in U.S. Are Losing Ground In Computer Education
Lack of Funds Leaves Schools With Too Few Teachers And Inadequate Facilities
Industry Gives Helping Hand

By Carolyn Phillips
Staff Reporter of The Wall Street Journal
URBANA, Ill.—It hadn’t seemed like an impossible dream. After two years at Eastern Illinois University in Charleston, David Gerdes decided to transfer to the University of Illinois here to study computer engineering. He had the science and math courses that the University of Illinois requires for admission. He had good grades from Eastern—almost a B average. He had A’s in all his computer-programming classes.

But with qualifications considerably better than average, 20-year-old Mr. Gerdes can’t get into computer engineering at Illinois. There isn’t room.

Even though overall enrollment is dwindling, U.S. colleges and universities can’t accommodate the hordes who want computer education. Good students are denied admission as many schools cap enrollments at levels that already strain teaching staffs and overtax facilities. In fact, some educators say that to guarantee quality instruction, they would have to reduce current enrollments in computer courses by 25%. Meanwhile, employers lament that only 50,000 graduates were available last year to fill more than 115,000 computer-related jobs.

“This country could blow what is a terrific world lead in computer technology by failing to graduate enough people with the capability to maintain it,” warns Robert G. Gillespie, the vice provost for computing at the University of Washington in Seattle. But without money to augment inadequate facilities and increase staff sizes and salaries, recession-whipped schools will continue to produce insufficient numbers of computer-trained graduates and will fail to effectively introduce the computer as a learning tool in nonquantitative disciplines.

Awkward Choices

The conditions force would-be students of computer sciences or computer engineering to make some awkward choices. Mr. Gerdes, for instance, is enrolled in the college of arts and sciences at Illinois and is trying to raise his 3.9 grade-point average to 4.2, the current cutoff on the five-point scale for the admission of transfer students into the engineering program. James N. Snyder, the head of computer science at Illinois, calls 4.2 “ridiculously high” as an entrance requirement. The required grade for general admission to Illinois is 3.25.

Mr. Gerdes’s chances for admission to engineering at Illinois “are probably diminishing instead of increasing,” says Gary R. Engelgrau, the director of admissions and records. By the time Mr. Gerdes attains a 4.2, if he ever does, the cutoff point could be pushed higher, as thousands more students continue to compete for the limited number of places. “You have to be a genius to get in,” says Mr. Gerdes.

Life on the inside makes other demands—including patience. During peak periods, as at many institutions, students wait hours to use a computer terminal for sometimes just a few minutes. They also stand in long lines to talk to a professor or a teaching assistant about computer assignments. One of the biggest computer-education headaches is that classes fill up so fast students can’t always get into the courses they need to graduate; as a result, a traditional four-year degree often takes an extra term or two for some students to complete.

Teaching overcrowded classes is no more fun than taking them. “Clearly, the ideal situation would be for me to have two students come to my office and have tea or sherry and talk things over,” says C.L. Liu, a professor of computer science at Illinois. Instead of tea for two, Mr. Liu has 200 to teach. He does concede, however, that such a large group isn’t necessarily a bad thing. “I think I am able to have some dialogue with large classes. I prepare better for them. I psych up a lot more, and I’m more animated.”

Watered-Down Education?

Mark Ardis, an assistant professor at Illinois, taught 18 students in a software-engineering course the first time the class was offered a few semesters ago. The second time the course was offered, 42 students took it. Mr. Ardis recently saw registration figures for the third offering of the class—126 students signed up. “There isn’t much change in my presentation of material, whether I’m talking to 10 or 120,” Mr. Ardis says. “What changes is the work done by the students. With a smaller group, I assign work I will look at and take an active role in grading. But with so many students, I will now give out assignments that only graduate teaching assistants will see.” He adds: “I think you water down the education when enrollment goes up.”

But do we see a deterioration in quality in a general sense,” says Edward Ernst, the school’s associate head of electrical engineering. “Faculty overload is the big problem. But we also aren’t able to keep up with the equipment we need for general instruction in engineering, especially in the computer areas. It’s a matter of having twice
Continued from First Page

the number of students with no additional resources.

Throughout the country, educators marvel at how quickly student use of computer facilities expands to fill available capacity. "It's like the Santa Monica Freeway—expected to handle traffic for 20 years and overrun in one," says Joel Moses, the head of electrical engineering and computer science at Massachusetts Institute of Technology. Robert Knight, the manager of Stanford University's LOTS (low-overhead time-sharing) computer facility, says, "You'd probably be hard pressed to find a school that is keeping up with student demand for computing capacity. To meet that demand you'd have to spend extraordinary sums of money.''

Extraordinary sums of money are being spent on university computer use—$1.3 billion a year, from the most recent estimates. "But more than half of that is for administrative purposes, hiring instruction and research," says Mr. Gillespie at the University of Washington. The amount spent on academic computer work translates into about $21,000 per student per year, only one-third the $60 per student that was recommended in a 1967 report by the president's Science Advisory Council.

Even at the best schools, under-investment in computers for instruction results in penny-pinching compromise. At Stanford, Mr. Knight says, "We're probably a little bit behind the times in terms of white-bang hardware," because the computer facility there just bought a second machine identical to the one in 1974. Sticking with the same machine meant the facility could use the same software and staff—two areas where costs are much higher than hardware costs. Although the purchase doubled the capacity of Stanford's LOTS facility, Stanford's vice provost Gerald Lieberman says student use increased accordingly. Mr. Lieberman projects LOTS will have to double capacity again—adding two more machines—in three years, if not sooner.

Most schools tolerate a certain degree of antiquation in the machines they use in general computer computing, citing capacity as the more important concern. (Specific academic departments may buy more modern machines for exclusive research or academic use.) But many schools question whether the limited capabilities of yesterday's computers are adequate, even for instruction. "We have to give students a sense of what the field is like today, not what it was like 10 years ago," says Kenneth W. Kennedy Jr., professor of mathematical sciences at Rice University in Houston.

Providing sheer capacity (enough terminals, enough computer power) constitutes challenge enough for computer-center staffs as they serve the needs of traditional student users—business, science and engineering majors for whom the computer is often the subject of study. But many bland at the thought of having to provide adequate facilities for all other students, too—students in literature, theater, history, religion, sociology and other disciplines who could use the computer, not for manipulating numbers, but for processing information. Educators see that as the next crest, an innovation in education termed a revolution by some. "But unless something changes drastically, the nation's best universities won't take part in this revolution," says Douglas Van Houweling, the vice provost for computing and planning at Carnegie-Mellon University in Pittsburgh.

Still, the most pressing problem in computer education is not machine obsolescence or lack of capacity or under-use of computers in nontraditional areas. The toughest problem remains the computer manpower shortage. Because of the short supply, industry offers high salaries that entice students with two-year, four-year or master's degrees into the workplace. So few students continue for the doctoral degree that the pool of people qualified to teach computer courses is drying up.

An American Association of Engineering Societies survey shows that computer-science and computer-engineering departments report a 17% vacancy rate—at a time when the 9% vacancy of engineering-faculty positions is considered a crisis. Jack Gels, a project director at the association, says that more than half the two-year computer-related departments date from a year ago or longer. Mr. Ernst of the University of Illinois adds: "More money alone to hire more faculty in computer science wouldn't help. We can't find anybody."

Salary Disparity

Only about 250 people a year complete doctoral degrees in computer sciences, and that number has been decreasing 6% to 8% annually, says John Hamblen, a University of Missouri professor on leave to the National Bureau of Standards. In the competition for those graduates, universities lose the salary bid. "A person with a two-year degree can get a programming job for $20,000 to $22,000 a year," estimates Andrew Molnar, a project director at the National Science Foundation. "A person with an eight-year Ph.D. might make $20,000 to $21,000 a year as an assistant professor."

The drawing card that universities once had—ambiance conducive to scholarly thinking and research—is deteriorating in computer disciplines. Illinois assistant professor Mark Ardis says, "It's hard to stay at a university when there are offers from industry at two or three times your salary and better research equipment, too. And besides teaching and trying to do research here, I advise about 85 students. For the first few weeks of the semester, there is a student outside my door every minute of the day. No one goes tenuring for advising students.

Mr. Kennedy at Rice warns, 'You can't get faculty get buried or they will leave.'

Aware that it has been eating its own seed corn, industry has moved to remedy part of the manpower problem in colleges and universities. The American Electronics Association and some of its members—notably Hewlett-Packard Co. of Palo Alto, Calif.—have developed a fellowship program designed not only to increase the number of doctoral students in computer sciences and electrical engineering but also to encourage the students to take teaching jobs after graduation. (The program waives part of the student's debts if the graduate takes a university faculty position after receiving a degree and waives the whole cost if the position is held more than three years.)

"We know if we don't make an investment in the development of engineers, then we won't have an industry, at least not one that's competitive internationally," says Pa-

tricia Hill Hubbard, president of the American Electronics Association's Electronics Education Foundation. She adds: "We also know that we're already late. We should have been doing this five or six years ago."

Fellowship Programs

A number of companies—Xerox, Standard Oil of Indiana, Control Data and others—have introduced fellowship programs, faculty research programs, equipment grants and other means of helping higher education train high-technology workers. Many schools are watching closely a joint venture between International Business Machines Co. and Carnegie-Mellon that will result in an industry in each student and staff member at the institution having a computer work station.

Colleges and universities are also beginning to see the necessity of increased support of computer education from within. "They see that a good computing facility is similar to a library. It's something without which a university can't exist," says John G. Kemeny, a professor of mathematics and former president at Dartmouth College in Hanover, N.H. The University of California system attacked the faculty-salary problem directly by raising engineering, business and management-faculty salaries across the board: 30% for assistant professors, 15% for associate professors and 5% for full professors.

In time, predicts John Hamblen of Missouri, the manpower shortage will work itself out—to a certain extent. He believes that as industry is saturated with two-year degree holders—as is happening now—more students will go on for the four-year degree. He worries, however, that the process won't correct the doctorate shortage for a long while.

But Mr. Gillespie at the University of Washington questions whether colleges and universities, even with industry help and the factor of time, will effectively be able to change the computer is bringing to education, without some sort of national agenda. "The computer affects the foundations of American education in a way that means we would have to examine how we provide that education," Mr. Gillespie says. "We're floundering right now because there's a need for the federal government to provide resources and information policies. That lack of direction on a national level has us standing at the edge of a cliff."

Campus Glitch: As Direct Result of Money Shortage, U.S. Universities Fall Behind in Computer Education
The academic world may associate computers with tech-savvy people, but one course in which a computer is used is English. The computer is used to check for spelling and grammar errors. The computer is also used to typeset and format the final draft of an essay. The program used for this purpose is called word-processing software.

The computer is also used to check for plagiarism. This is done by comparing the text of the essay to a database of known works. If there are any similarities, the program will highlight them. This is important because plagiarism is a serious violation of academic integrity. It is important to use the computer to check for plagiarism as accurately and efficiently as possible.

The computer is also used to create visual aids. This is done by using software such as PowerPoint. The user can create slides with text, images, and animations. The computer is also used to create videos. This is done by using software such as Adobe Premiere. The user can create videos with images, text, and sound. The computer is also used to create websites. This is done by using software such as WordPress. The user can create websites with text, images, and videos.

The computer is also used to create documents. This is done by using software such as Microsoft Word. The user can create documents with text, images, and tables. The computer is also used to create spreadsheets. This is done by using software such as Microsoft Excel. The user can create spreadsheets with numbers, formulas, and charts. The computer is also used to create presentations. This is done by using software such as PowerPoint. The user can create presentations with images, text, and animations. The computer is also used to create databases. This is done by using software such as Microsoft Access. The user can create databases with tables, queries, and reports.

The computer is also used to create games. This is done by using software such as Unity or Unreal Engine. The user can create games with images, text, and animations. The computer is also used to create simulations. This is done by using software such as Simulink or MATLAB. The user can create simulations with images, text, and animations. The computer is also used to create virtual reality experiences. This is done by using software such as Unity or Unreal Engine. The user can create virtual reality experiences with images, text, and animations.

The computer is also used to create artificial intelligence (AI) systems. This is done by using software such as TensorFlow or PyTorch. The user can create AI systems with images, text, and animations. The computer is also used to create machine learning systems. This is done by using software such as scikit-learn or TensorFlow. The user can create machine learning systems with images, text, and animations. The computer is also used to create natural language processing (NLP) systems. This is done by using software such as spaCy or NLTK. The user can create NLP systems with images, text, and animations.
The Campus Race
For 'Computer Literacy'

LITERACY, FROM H1

Technical fields, she says, but "where an invention begins and where it ultimately leads are very different places."

"The real reason that the humanities have to take some leadership in this," she says, "is that we can't expect the electrical engineers to know what the humanistic concerns are that computers can serve ... We've got to get a critical mass of humanists who know about these things."

The innovators on campus, the gatekeepers, may appear in any department," says Andrew R. Molnar, a computer education specialist with the National Science Foundation. Certain schools, he points out, have established excellent reputations for their use of computers within particular fields without being across-the-board leaders in computing.

At the University of Chicago, a vast library of French literature having been stored and filed in the university's computer system for linguistic analysis and other purposes. The University of Iowa, as an experiment, has put a terminal on the desk of every faculty member in political science—for word-processing, data, and communications. And a unique "instructional design group" at the University of Minnesota creates computer programs for faculty members in all fields. Among the results is a line of software law-school instruction programs (to be marketed in partnership with Harvard) that enables students to have Socratic dialogues with their computer terminals. "It's the Kingsfield-in-'The Paper-Clash' sort of dialogue except it's done through the computer program," explains Russell Burris, professor of law and instructional psychology at Minnesota.

Computer use is one area where the oldest and best-endowed schools are not invariably the leaders. In Sift's subjective opinion, George Mason's approach compares favorably with the much-vaunted "core curriculum" program unveiled four years ago by Harvard—an initiative many critics found disappointingly traditional and whose lack of daring was widely attributed to the strong attachment of Harvard's well-entrenched faculty to established courses and specialties.

George Mason's new program represents a major break from the past, according to Sift, and he attributes his school's willingness to make that break in part to the fact that it is only 10 years old, with a correspondingly small number of tenured faculty members of middle years and beyond. Size is also one of the factors that govern a school's flexibility.

"The average public institution is lucky if it can give 10 hours of [computer time] per student per year," says Robert Gillese, vice provost for computing at the University of Washington, whose student body numbers 33,000.

By contrast, Gillese cites the example of Dartmouth, where the average student gets upward of 50 hours of terminal use a year. At Dartmouth, 96 percent of students get "hands on" experience and 75 percent are regarded as "computer literate," according to a recent survey. There are 600 terminals on campus for 4,000 undergraduates and 900 graduate students.

Under its former president John Kemeny, who once served as an assistant to Albert Einstein and later helped conceive the computer-programming language called "Basic," Dartmouth became an early pace setter in computer research and instruction. Kemeny sought to make computers as accessible to students as books. Thus the Dartmouth computer facilities are open around the clock and available to any student free of charge and without scrutiny of his purpose. Dartmouth has, in Molnar's phrase, "a computer culture" on campus.

As fast as many colleges are moving, it is not fast enough to suit all. "Computer literacy" is a goal that, in many minds, comes chained to a threat—the threat of rampant "computer illiteracy" in an age when, professionally speaking, that could be fatal.

"We may be creating an underclass of people who are not only unemployable, but undesirable," says the NSF's Molnar, "because they complete the school system without having had any experience with computing." Because of computers, Molnar says, there has been an "information explosion" rendering the body of documents and data in almost every field vast that "nobody can know anything anymore, they can only know where to look." And "knowing where to look means knowing how to use computers."

In Thomas Jefferson's time, 3,000 books was a library," he says. "Now we're talking about millions of documents such as it takes about 23 years to read all of the things you'd need to know in chemistry alone." In economics, astronomy, genetic sciences and other fields, schools with inadequate computer facilities, and the students who go there, "are out of big science, are precluded from doing cutting-edge research," says Molnar. And the country as a whole, he warns, runs the risk of falling behind such nations as France and Japan, which are investing in computer instruction at a rate that only centralized systems can do.

Computers, in short, have produced a "discontinuity in our society that our educational system is failing to meet."

Not everyone shares this sense of crisis about our educational system's state of readiness, and not everyone accepts the computer-in-every-book bag solution. But however urgent the problem may be on the national scale, it has become desperately urgent for individual institutions grappling with diminishing enrollments and cramped budgets. The ability to lure computer-conscious students is becoming "a matter of survival for many schools," according to Francis E. Masat, professor of mathematics and computer science at Glassboro State College and author of "Computer Literacy in Higher Education," a report published by George Washington University's Clearinghouse on Higher Education.

"Many schools have some difficulty in trying to project just what the impact is going to be," says William Rambo, director of GW's Center for Academic and Administrative Computing. "But the schools that just turn on the break on the problem is making a big mistake."

Unfortunately, the academic world is widely perceived as slow-footed by its nature—a tortoise racing the hare of American commerce. Teachers trained and tenured in a computer-free age are unifit, it is argued, to decide what the next generation of college graduates ought to know, or, even if they perceive the need correctly, to act on that perception.

A shortage of computer-literate faculty may be the biggest single problem, and there is by all accounts, no solution in view. In 1980, there were 12 jobs for every holder of a bachelor's degree in computer science, and 34 for every holder of a doctorate, with a predictably large gap between the salaries offered by industry and academia.

In 1967, the President's Science Advisory Committee declared: "After growing wildly for years, the field of computing now appears to be reaching its infancy." Fifteen years later, most experts believe the proposition holds as true as ever. The greatest changes, they say, still lie ahead.

"When I started in school," recalls Robert Gillese, "I bought a slide rule that cost me about the price of 10 books, and I have a theorem that says when the price of a computer for word-processing comes down to the price of 10 books, everyone will buy one. And that's not so far away."

The Campus Race For 'Computer Literacy'