MIT's PROJECT ATHENA

A five-year study examines the role of microcomputing in education

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What place do microcomputers have in higher education? At the Massachusetts Institute of Technology in Cambridge, Mass., a massive five-year experiment, called Project Athena, is examining that question.

While microcomputers are springing up on many campuses, MIT's project is uniquely ambitious: Athena will make it possible to link Digital Equipment Corp. terminals and IBM workstations on the same network so that users can share any resources they wish. A campuswide network will serve as many as 10,000 users.

Begun in May 1983, Athena, named after the Greek goddess of wisdom, received a total of $50 million from IBM and DEC, both of which have permanent staffs on campus to assist with the project. Though there are no planned commercial products as such, the project will have wide-ranging commercial implications for both IBM and DEC, primarily by providing both companies with a large-scale laboratory environment.

MIT is raising $20 million for the project, half to subsidize faculty activity over the five years to develop computerized curricula. Every department is participating, including humanities and social sciences as well as the architecture and planning, science and engineering departments.

Altogether, there are some 70 curriculum-development projects in the works, covering everything from the teaching of civil engineering to foreign languages and creative writing. The MIT faculty has very quickly taken up the challenge of computerizing curricula, and some courses are already being tested in the classroom. A number of these projects rely on artificial-intelligence techniques to teach logical processes and problem solving (see related stories).

Technological feats aside, Project Athena is inevitably confronting many concerns voiced by today's educators about the proper role of computers in education: Will the computer replace the teacher? Will the computer finally dictate what is taught by emphasizing technological subjects that unarguably benefit from computerized teaching over liberal arts courses that are more difficult to translate into computerized curricula? Is using a computer actually an effective way of learning?

In keeping with these concerns, Project Athena is not a huge experiment in the possibilities of computer science, according to the project's executive director, Steven Lerman.

"Basically, it's an educational project," he said. "This could easily become a computer-science playpen, but it won't. The project's 'mission' is to develop a long-term base of information that can provide guidelines on how the university should approach microcomputing as a teaching tool."

The real focus of Athena is to examine whether students learn better by using microcomputers, Lerman said.

MIT has no intention of replacing teachers with computers and sees no practical value in the traditional forms of computer-assisted instruction. "What universities teach is far too abstract to have computers do that meaningfully," Lerman said. In MIT's new computerized courses, the computer will be only an adjunct tool.

But it will be a tool with new and valuable abilities, a tool that can enrich students' learning and teach in ways

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By Patricia Mandell, Special to PC Week

Project Athena

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never done before. Lerman cites two examples. A quantitative-physiology student might run complex differential equations on the computer to simulate the effects of changes in the heart and lung systems. Ordinarily, the results of these equations are too complex for a student to interpret and intuit their meaning. Another example is that three-dimensional graphics are ideally suited to help students visualize concepts graphically. A 3-D program could show a student what an electromagnetic field is supposed to look like.

As the project nears the halfway point, much has been established and much has been learned about the challenges of what Lerman calls "this massive and slightly crazy exercise."

In the fall semester, students began to use Project Athena workstations to do homework for the very first time, notably in the school of engineering. Already, Lerman said, students report deeper understanding of course material as a result.

Phase one of the project involved using existing equipment in 1983 to try to build the Athena environment. To begin with, this meant using DEC VAXes and terminals, IBM PC XTs and ATs, Lerman said. All hardware was to work under a single operating system: Berkeley Unix 4.2. The ATs used in the first phase use a PC-DOS environment that overlaps with some key utilities of Unix 4.2, Lerman said.

The Spine of the LAN

The campuswide network is a spine to which many local area networks will be connected, each with its own MIT-designed interface and gateway. The spine is a fiber-optic, ring-topology network with Microvax gateways to Ethernet LANs.

"Basically, you can hook anything you want to this network," Lerman said. In the future, he envisions gateways to a supercomputer and outside networks.

The spine network is actually a university project that goes beyond Athena, but Athena fueled its beginnings and, as its largest customer, has a big say on its use. Most of the Athena LANs will be "public clusters" of workstations—say, a network of six or eight workstations located in a public place for the use of students. So far, there are 11 public clusters in various class buildings and one in the student center.

Now that most academic areas have public clusters, the "living groups," or dorms and other housing, will get microcomputers. There will likely be one workstation for every eight to 12 students in the living groups, Lerman said.

As the end of the first phase nears, and the second phase approaches, the project is just starting the switch from time-sharing to distributed workstations. There are 158 ATs and about 500 "other" workstations under Project Athena: DEC terminals and IBM PC XTs in terminal-emulation mode to 53 DEC VAX-11/750s.

The original target was 2,000 to 3,000 workstations, which would serve a faculty and student population of about 9,000. The target number was based on economics and on providing a healthy ratio of machines to students. The aim would not be a one-per-student ratio, but enough machines to make students feel that a computer is always close to them and always available.

Whatever the total, the final aim is Unix-based, 32-bit single-user workstations with a minimum of 1M-byte storage and high-resolution graphics—traits now embodied in DEC's Microvax II, announced last spring. "That's where we're headed," Lerman said. Right now, Athena has 25 Microvax IIs, and by the end of the academic year there will be about 150.

Some students, reported William Hogue, Athena's assistant director, have objected to the Microvax II, saying it is a "Porsche" when a "Volkswagen" would do. But, he added, "If we are to be in the vanguard, we have to have the same tools in the hands of the students as are in the hands of the people developing the software."

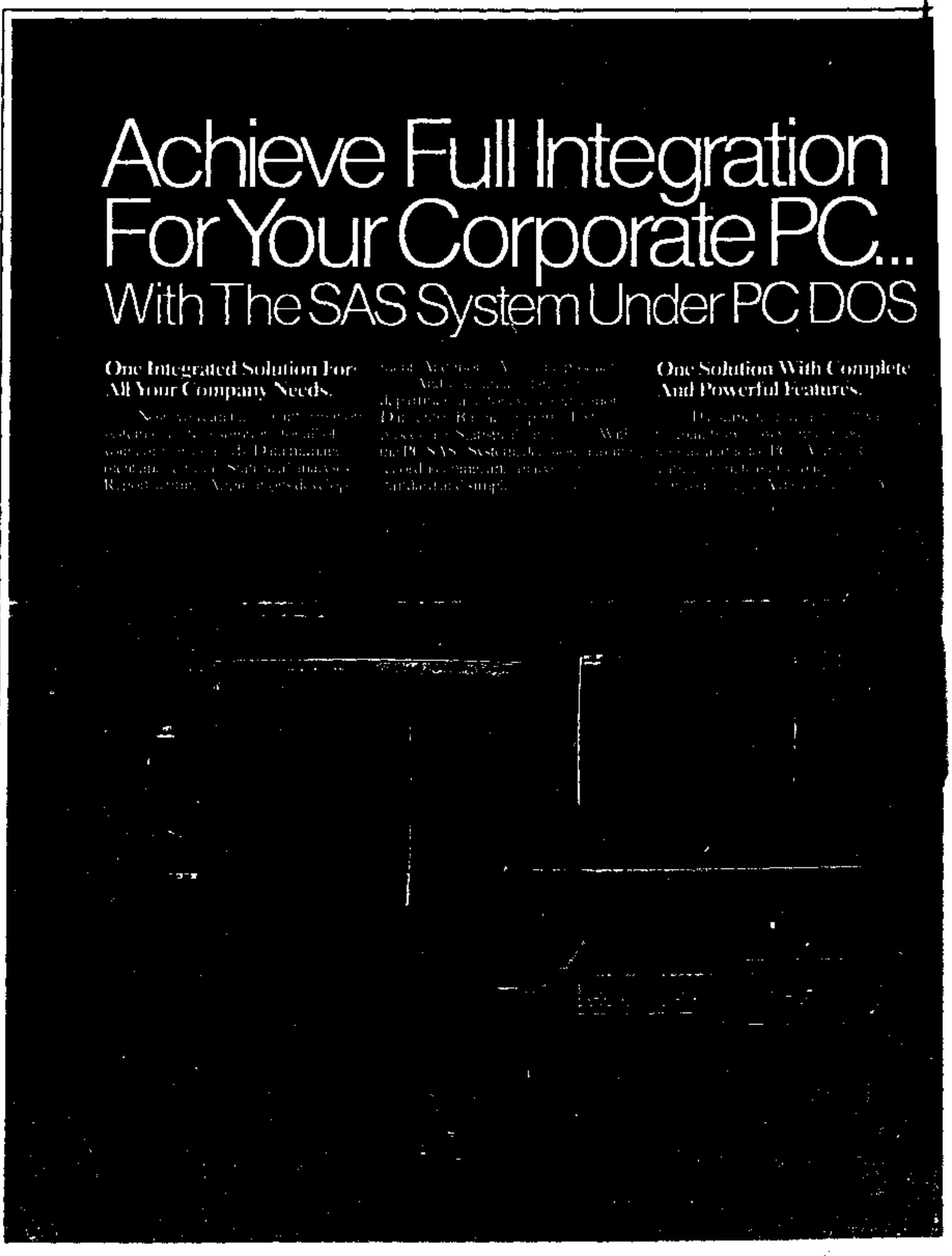
Project Athena has a communications protocol and supports four languages: C, LISP, FORTRAN and Pascal, the last of which is rarely used in the MIT community. A windowing system developed by MIT runs on the Microvax IIs and the DEC terminals.

Athena also supports about eight packages that run under Unix, including a database manager, spreadsheet, text editor, the window manager, a laboratory data-analysis package and a graphics package.

Although many interfaces have been designed and built to integrate various parts of Project Athena, true integration is still a goal, Lerman said. "Coherence" is what he calls it: a set of goals to allow "a high degree of interchange" among different users. Coherence should allow any two users to share disk space or programs, or any file to be output to any printer.

"The current environment has all sorts

Patricia Mandell, a free-lance writer based in Marshfield, Mass., is a frequent contributor to PC Week.



[illegible] inconsistencies that [illegible]. We're trying to flatten the important ones," Lerman said. A [illegible] would make different computers transparent to the users, so they need never worry about their own particular configuration.

Ironing out inconsistencies is complicated when working on such a large scale as MIT is doing. Certain unforeseen and unique problems have cropped up because of the size of the network and the user population. One is the need for a type of printer that doesn't actually exist.

Athena needs to put printers to work in public clusters. To be cost-effective, these printers should be high-duty ones that come with network attachments and large paper trays for unattended runs.

Ideally, they should be laser printers. But there are two extremes in laser printers: very large and very costly, and very small printers with low-duty—as opposed to heavy-duty—cycles. Athena is now relying on heavier-duty line printers to serve the public clusters, with personalized laser printers as specialized printers. Athena also provides a Xerox 9700 for high-volume, high-quality printing needs.

Another problem was the need for electronic user-account management. Two thousand new students register each year at MIT. Each needs a password and logon to the network. This is far too massive a task for staff to handle, so a system had to be designed to have the network handle the accounts. On a smaller scale, "You wouldn't even know you needed it," Lerman said. "You only discover certain

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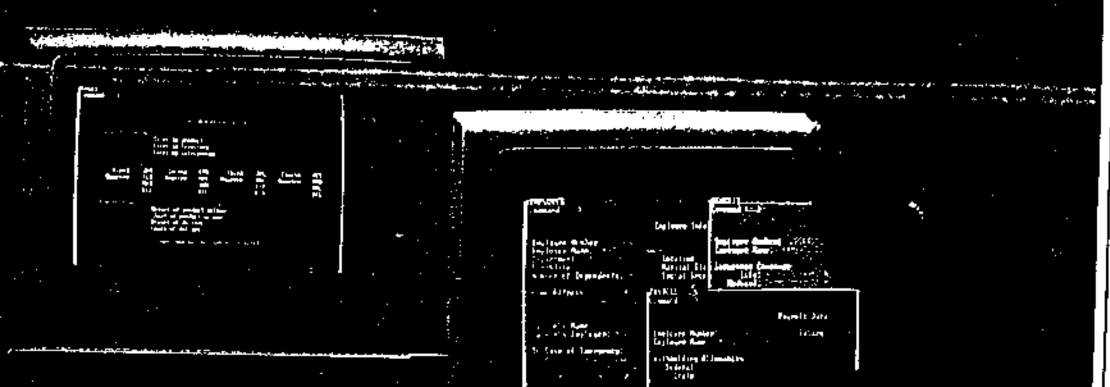

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Under Athena's Rule, Learning Espanol Is More Interesting

An amnesiac has left some recombinant DNA in Bogota. You must find out where it is before disaster strikes. But the amnesiac speaks only Spanish.

This exercise is one of a set of software programs designed for the IBM PC AT to help teach foreign languages at MIT under Project Athena. Several programs, including the one in Spanish, are in experimental use for the fall semester.

The Spanish program requires students to move to a far more personal level of conversation, and requires elaborate levels of questioning. The emphasis is on discourse rather than rote drill, a far more effective method of teaching languages, according to Prof. Janet Murray, who directs this project as well as another that is aimed at integrating micros into the teaching of writing.

The software program for teaching writing is an outliner, tied to a text editor, that makes it easy for the writer to move sections. Murray reports that it is also a real antidote for writer's block, because it tends to free up inhibitions about writing. She believes that writing on a computer encourages revision and putting down uncensored words. "That's very good for freeing up writer's block," she said.

The foreign-language project is based on artificial-intelligence techniques, and naturally, it helps to be on the scene of a cutting-edge laboratory such as MIT's. The foreign-language project has received help from a computational linguist in MIT's AI lab.

The main task, Murray said, was to develop an AI-based system that could build exercises that have the form of conversation. One experimental program is called "LINGO" (language instruction through graphics operations).

Poltergeist

This program asks the student to have a conversation in German with a poltergeist about a room on the screen that they will mess up together.

The student must follow conversational guidelines to move objects in the room that are represented graphically on screen. The messed-up room will be stored so another student can retrieve it and clean it up.

In both exercises, the poltergeist uses natural discourse. It may request clarification, suggest grammatical changes or give the listener feedback. The program's interactive audio will help the student with intonation, giving immediate feedback on his utterances and capabilities. The interactive-video portion could also be used to bring in native speakers so students could hear pure accents.

The AI-based system is modular, which means the rules of one language can be removed and those of another plugged in.

According to Murray, using the computers can give students a different notion of learning languages than they get from a meaningless drill. "This is a new medium. This is really teaching foreign language in a way it's never been done before, using computers in a way they've never been used," she said.

One thing's for sure: This is a long way from *la plume de ma tante*. —*P.M.*

Project Athena

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things through [working in a] large scale."

Another "reality" of a project this size is that "something's always broken," Lerman said. "It's just a question of time until something breaks because you have so much hardware."

The size of the project also creates "some extremely difficult logistical problems," Hogue said. Not the least of these is that both MIT and the greater Boston area have critical housing shortages. Many MIT students live on the Boston rather than the Cambridge side of the Charles River, or in other nearby communities. Fraternities and sororities must be considered part of the university housing, too, but many of those are not on campus either. "How do we distribute workstations equally and fairly to all living groups at the same time?"

Moreover, those widespread locations will be difficult to link to the network, Hogue added.

There is also a space crunch on campus, making it hard to find good places to put computer equipment.

"High-quality" space—centrally located, with easy access and in a suitable environment for computing equipment—is at a premium. Athena has had to compromise more than once on its space requirements, and some equipment is in basements. There was no other space for some VAXes than in rooms without air conditioning, so MIT built special water-cooled cabinets for these machines, and calls its new hybrid a "Hydrovax."

One of the most popular Athena clusters on campus is one in the student center, which helps to give the project some visibility, promoting interest.

MIT students are mostly very aware of Project Athena, and very interested in participating. Although about 25 percent arrive with their own hardware, the rest arrive looking for their microcomputers.

Lerman believes this is the way it should be. A microcomputer should be an expected part of university equipment, just as telephones are. "I see the university in the future treating computing like a utility," he said, "because it's so integral to what universities do." Microcomputers, he believes, should be a resource no different from heating or power resources.

Much work remains to be done on the project, and there are plenty of related possibilities, such as linking computerized library information to the network.

"Athena is huge, but it's not going to be able to do more than a small fraction of what's needed to be done. It's as if a university [were] to set out to try and write every text [that a university uses]," Lerman said.

Still, the implications for all participants will be profound. In formal agreements drafted with IBM and DEC, MIT owns all "work products"—whatever code or other resources are invented. Neither company has a direct financial stake in the project, but "They have Athena as a laboratory for large-scale ideas," Lerman said.

The two companies will learn how their products fit into a university environment or other similar large-scale industrial locations. "We act as a laboratory of the future," Lerman said.

The whole project continues to be experimental, which means that one possible conclusion will be that microcomputers are not a valuable tool in teaching university courses. That, however, seems unlikely in view of the ground already broken by MIT faculty.

Lerman does not expect to see the real goal of Project Athena accomplished until the late 1980s: to have the computer be an integral part of the curriculum.

If that is achieved, microcomputing could represent a fundamental change in education. ■

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Using AI To Engineer New Software

While computer-aided drafting was an innovation in its time, the teaching of engineering is due for some new tools—artificial-intelligence-based software, according to John Slater, an MIT assistant professor of engineering.

Slater is spearheading the development of such software under MIT's Project Athena, some to run on DEC VAXes, and some to run on the IBM PC and AT.

Engineering applications are ideal for AI techniques, he said, because many problems don't have clear-cut answers, but are based on applying rules of thumb. And expert systems can do the job.

A key aim for Slater is to put knowledge about the engineering process into the software and to make it visible to the user; to make the software "work like an intelligent assistant to the engineer, not automate the process," he said.

"Our solution is to have the software emulate what the teacher would do—to make the student think more deeply," he said. The important thing to demonstrate, he added, is the process of arriving at the answer.

The Tutor Program

Slater has looked at several types of software, some of it design software, and some of it rule-based systems. One such rule-based program acts like a teacher, but gives individualized instruction. He calls it the "tutor" program, which is being field-tested this semester by 35 beginning-level engineering students.

The tutor program can solve problems of beams in building construction—predicting and solving stress reactions in a beam—and teach the student the process, too. The student can be presented with a problem to solve or input a problem he would like to solve. A built-in calculator handles equations. The program will solve the problem with the student, so he can compare his answer. The program can show the student the process as well as the answer.

The tutor program can also diagnose mistakes by allowing the student to ask questions about what's wrong with his answer. The program might respond that the equation is wrong. The student can then ask why, and the program will respond with more specific information: A mathematical sign is wrong, a coefficient is wrong, or something is missing. Getting even more specific, the student can then ask why the sign or coefficient is wrong. The tutor program will form "the keystone" of a number of programs to be produced, Slater said.

Though it has been designed to apply to beam problems, it could apply to any course material, such as pulley problems.

The tutor program runs on networked Project Athena VAX terminals, and is menu-driven with built-in, on-line help. Students will be polled on whether the software helped them, how it helped them and what changes they'd like to see.

Another program under development will build numerical models of civil-engineering structures. You can't exactly try out building designs in a laboratory, and many structures are difficult to visualize. But with the modeling program, students will design a steel building graphically on the screen, figure geometry for the beams and calculate stresses and loads. For a student to do this by hand with a calculator would take weeks. The speed of the program lets the student learn faster, Slater said.

Another rule-based expert system under development will look at more complicated problems of engineering design and configuration. It is called an adviser, Slater said, and it can help a user choose an appropriate configuration or weigh the design methodology. It's more sophisticated in terms of the information it contains than the other programs.

While the rule-based systems under design at MIT are new, this type of software is an inevitability for engineering students, said Slater. "This is the way they're going to do engineering when they get out in the real world."

—P.M.