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FREUDBERG: Project Athena is a pioneering experiment in education at the Massachusetts Institute of Technology. Its overall goal is to find out how the latest computer, communications, and graphics technologies can enhance all phases of the learning process. It can help students grasp fundamental concepts, develop intuition, and tap their creative abilities to the fullest.

The basic tool of Project Athena is a campus-wide network of over 2,500 computer workstations now being installed. This system will help students and teachers not only create innovative, educational software but also to share programs, to exchange data, and to communicate with greater ease than ever before.

Already, students and faculty are demonstrating the promise of Project Athena. All across the campus, students are using the new computers help gather and analyze experimental data, to visualize abstract concepts and principles, to model physical systems, and to simulate complex processes.

STUDENT: This is the right heart. This is the body. And this top part right up here are the lungs.

UNKEL: Take a sequence of values.

FREUDBERG: In the Department of Mechanical Engineering, for example, Professor Bill Unkel was using an Athena computer to operate like a powerful oscilloscope. Not only does it help students gather data and plot it on a screen, but it also allows them to compare it to theoretical predictions right in the laboratory. For this experiment, the students are examining what happens when a simulated nuclear fuel rod accidentally falls into a reactor.

STUDENT: What happens when the cylinder hits the snubbing section when we let go of it is that the snubbing section is narrow enough so the air is compressed and acts as a spring so the cylinder bounces up and down a few times, which is what is recorded on the oscilloscope, which is the computer.

UNKEL: The thinking part of it is really what they have to do. What the computer does do is to help them to see the results more graphically. And it helps them to make much easier comparisons between theory and experiment and to follow up on ideas much more quickly.

STUDENT: Gives you a chance to take all the equations and all the things you've learned in thermo and fluid mechanics and system dynamics and actually see it put to work in a real situation.

FREUDBERG: Across the campus, students in Professor Jeffrey Steinfeld's undergraduate chemistry lab are preparing a sample for the infrared spectrometer. In this case, after an Athena computer collects the spectral data, the students can manipulate and analyze it at the terminal without having to leave the laboratory.

STUDENT: Right now, right now, the valve is closed here.

FREUDBERG: In these and other experiments, the computer makes it easier for the student to test the relationship between theory and experiment, to play with the experiment, to explain unforeseen results, and in the process, to come to a deeper understanding of the underlying principles.

Another emerging use of the computer is to help students visualize abstract concepts and invisible phenomenon. Computers are uniquely suited to translate the complex mathematical formulations of these concepts into simple graphical form. This greatly extends the students' ability to see, test, and understand the real physical meaning behind the equations. For example, in one class in the Department of Electrical Engineering and Computer Science, a program allows students to actually see the intricate three-dimensional form of electric fields.

STUDENT: One of the advantages that came right out of the first hour of my sitting down here and working at this was that the method that they had given us for drawing out these waveforms was a good method, but I had it wrong. I had mistakenly forgotten a factor of two for a graphical method of solving these things.

That came out just right away as I was looking at this. But I have been using that method for three weeks on about three different problem sets, and I hadn't found out that it was wrong, so the visualization brought that to my attention right away. It'll help me develop an intuition about what should happen.

Over in the Department of Material Science and Engineering, students using a program developed by Professors Julian Szekely and Terry Ring with the help of a graduate student can enter physical parameters into a computer model describing fluid flow.

RING: We have the ability now to do things that you really couldn't present in a lecture. You had before a very qualitative graph on the board that you could put in with some chalk. But now the student has the ability to see the actual graph and manipulate it and change it with different parameters into it to see what the effects are for the first time.

FREUDBERG: In seconds, the computer grinds through the lengthy numerical calculations and produces a graphic display of the stress and velocity profiles, which summarize the behavior of the fluid.

SZEKELY: That is crucial that we really want to intertwine the thinking process of the student with the working of the machine.

FREUDBERG: In another corner of the campus, undergraduates in an ocean engineering subject use a new interactive program to test the seaworthiness of ship hold designs, modifying the design until it meets the specified requirements.

STUDENT: You can do any design you want and see what it would do. Things that if you were doing by hand you probably couldn't afford to do because it would take you hours to do and then to plot it and see where your water line was and different things, difference in drafts. But having this program, you are able to do a lot in very little time.

If you're in class and they tell you, well, a really skinny ship will be really unstable when its upright, but then it'll be even more stable when it's heeling. And then you would say, well, OK that makes sense, but you don't really get a feel for it. But when you're doing it here, you'd really see what it does and how it behaves, so it makes you really get a grip of what you're learning.

FREUDBERG: Some subjects pose special challenges to the teacher. For example, it's very difficult to convey how the various components of the cardiovascular system interact dynamically inside a living organism. Now students in Professor Roger Mark's class on quantitative physiology can experiment with a computer simulation of the cardiovascular system, seeing how changes in each part can affect the whole system.

STUDENT: There are two other ways that you could do the experiment. One would be to take the model, which has six differential equations and try and solve them all. And it would just be ridiculous. The other way, of course, would be to take a live patient and perform the experiments. But there you're limited because your don't want to kill the patient or push his system too far.

For example, usually the body, to increase the resistance in, say, an artery, it constructs the artery. Here, we can change the resistance and keep the artery at the same capacity right there, something you couldn't do in real life. But we can see how it reacts on the computer.

STUDENT: Well, I thought about the heart and thinking about how do you increase your blood volume, say. How do you get more blood out to the rest of your body? The first thing I think of is make the heart beat faster. That does work to an extent, but after seeing the model, you can see better ways to get more blood out in the volume like increasing resistance and something like that.

And just thinking about it or reading it, you just think, oh, that's not the proper way. But when you come up here and find which way can I increase the blood volume the most, and actually try all the different ways in just a matter of minutes.

FREUDBERG: In other subjects, the Athena system may make even more fundamental contributions. Architecture students, for example, have long used pencil and paper to develop their design ideas. Computers, however, are a new tool that may spur creativity by offering the potential for more flexibility, better visualization, and faster iterations through the design process.

PROFESSOR: For years in the department of architecture at MIT, they've been talking about the advantages of using kits of parts and that things get built up. But it's been very hard to learn it as a design method, because of the amount of logistics involved. But what the computer allows you to do, because you build a data file and you build this kit of parts, is it allows you to manipulate it instantaneously. So it's much easier to come to an understanding and to come to terms with what it is you've got to deal with. The machine will help you to develop your own intuition about design because it helps you to learn about the pieces of design as fast as you can move.

FREUDBERG: The ultimate goal of Project Athena is to make education a richer, more effective, and more rewarding experience. As Athena evolves over the coming years, it will give the faculty, students, and staff the opportunity to test more ideas and to discover new and even better ways to teach and to learn.

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