Science Teacher Uses Interactive Physics™ Application to Encourage Active Learning

SAN MATEO, California—April 3, 1997—After 31 years of teaching physics, Ray Smith knows what it takes to capture students' imagination and keep them motivated. And these days, he has a technology tool that makes that job even easier.

Smith teaches physics and physical science in grades 9-12 at Edmonds-Woodway High School in Edmonds, Washington. He uses Interactive Physics™, a modeling and simulation application from MSC.Software, to challenge students to explore physics in a whole new way.

Interactive Physics gives teachers and students all the tools necessary to quickly build simulations and carry out almost any Newtonian mechanics experiment on their desktop computers. The multi-platform application allows students to use pre-built or third-party models.

Simulations extend laboratory experiments

"Interactive Physics is very easy to integrate into the curriculum," said Smith. "In any of the physical sciences, this program fits right in."

But an important first step, he said, is to show students that Interactive Physics simulations will give the same results as a textbook problem or an actual lab experiment. One way he establishes students' trust in the application is by comparing the velocity of a real swinging pendulum to the velocity generated by the simulation. "When students see similar results, they begin to think of other ways to 'test' the software's capabilities," he said. "This often leads to real involvement in thought and application of physical concepts."

In another case, he uses air-track experiments designed to discover the relationship between the angle of incline and the acceleration of a glider down the track. He starts the experiment in the lab, with a slight incline of five to 10 degrees. Students change the value of the incline several times, but then switch to a simulation.

"With Interactive Physics, they can increase that angle of incline all the way from zero to 90 in five-degree increments," Smith said. "They can use Interactive Physics as an extension of a laboratory experiment to discover the mathematical relationships between the variables."

Simple modeling encourages active participation

"This program is very interactive and very intuitive," Smith said. "You don't have to be a computer whiz to create simulations that are very helpful in understanding abstract or complicated physical concepts. Many simulations help students 'see' what could happen in a variety of interactions."

With Interactive Physics, students also can make quantitative measurements by simply clicking on the object they want to measure (mass, spring, actuator, etc.) and choosing the measurement they need (time, position, momentum, etc.) from the menu. Measurements can be displayed in either graphical or numerical form.

He said students become adept at using the program after only a few sessions. And he strongly encourages his students to create their own simulations. "Creating their own models is very motivating," he said. "By creating a simulation in Interactive Physics to show what they are going to do or have done in the lab, they become more involved in the experiment. After creating a simulation of a lab experiment, students better understand how to set up a lab and what measurements need to be made to get the results they expect."

Examines a wide range of physics problems

Smith poses a variety of physics problems for his students to solve. "The interactive features of the program enable students to build simulations that demonstrate interactions between masses, springs and pulleys, and also vary the amount of friction or gravitational force," he said. "They can learn about simple harmonic motion, using a mass on the end of a spring and changing the mass to see how the frequency of oscillation varies."

He also gives them problems with pendulums to teach conservation of energy, an elusive concept that can be difficult to grasp. With Interactive Physics, however, simulations show the pendulum's movements in ways that cannot be done in an ordinary lab setting. "In its elevated position, a pendulum has gravitational potential energy," said Smith. "As it swings, it loses that energy and gains kinetic energy. With Interactive Physics you can display graphs to show how the two energies have to add up to a constant value for conservation of energy to occur."

Smith said vectors is another elusive concept that Interactive Physics simplifies. For instance, when examining two-dimensional two-body collisions, he introduces vectors such as force, velocity, acceleration and momentum. These variables are plotted visually on the computer screen as the simulation runs, allowing students to see how the collision is altered as the variables change.

Interactive Physics also makes gravitational and electric fields easy to examine. "You can create any kind of force field you wish," he said. "If you want to get into more sophisticated uses of the program, you can create force fields that will vary with respect to time, angle of rotation—all kinds of weird things that go beyond what you would have in a general textbook. So it gives you the opportunity to show that things don't work that way—it's kind of the indirect proof."

Smith's students learn about planetary motion through an experiment that requires them to use Newtonian formulas to calculate the orbital velocity of a satellite. "With Interactive Physics, they can set it up so the orbit is perfectly circular, and then increase or decrease the velocity by a small amount and find that it produces an elliptical orbit," said Smith. "In this way, they discover the Kepler laws of planetary motion. They can discover this by setting up several different examples and then graphing that data to find the relevant relationships."

The application is very versatile, he added, allowing him to tailor problems to the age and grade level of his students. "With Interactive Physics you can get concepts across to younger students without having to set up an actual lab or use a lot of math," he said. "For more advanced students I can throw in mathematical analysis, by having them link their data to a spreadsheet application."

Ideal lab results

One of the nice things about Interactive Physics, Smith said, is that the computer simulations eliminate friction and other problems encountered in an actual physics lab experiment. "It really gives you ideal results," he added. "You won't get ideal results in a lab experiment, but I tell my students that if they can minimize friction, they can get closer to what the Interactive Physics simulation shows."

Smith's students tend to take the challenge. "They say, 'Well, I'm going to make my lab experiment do what the simulation does,'" he said. "So it's a way of 'throwing down the glove.' It keeps the students interested. They tend to buy into what the course is about or what that particular experiment is about, and it gives credibility and continuity to the course."

A powerful teaching tool

Smith said Interactive Physics saves time, by allowing him to set up multiple problems quickly in advance. For instance, in two-body collision problems, he must calculate simultaneous equations for the conservation of momentum and conservation of kinetic energy. To set up multiple problems, ordinarily he would have to recalculate these equations for each new problem. But with Interactive Physics, he simply changes the variables, and the application automatically does the calculations.

“And if students need a tutorial, Interactive Physics is ideal because they can generate as many sample problems as they wish and then see if they can calculate them to find the answers, which they can compare to the answers I’ve written on the board,” Smith said. “This helps them absorb the concept, allowing the teacher to go on to other things. Also, with Interactive Physics, you can very quickly answer some of those questions that would be very difficult to answer in a normal lab. But with a simulation, you can easily show students how it would work.

“Interactive Physics is a very, very powerful teaching tool. I can set up a model that is the same as a problem in the textbook, or the same as an actual lab problem. I can run it through quickly to show the kind of data the lab would produce or the solution students should get in the textbook problem. And it’s dynamic. It encourages students to start asking ‘what-if’ questions.”

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