



PROMISING PROGRAM

# *Modeling Instruction in High School Physics*

# MODELING INSTRUCTION IN HIGH SCHOOL PHYSICS

## PROGRAM DESCRIPTION

Modeling Instruction in High School Physics, started in 1990, uses computers to teach models and modeling, central components of modern science. These components are focal points to develop the content and pedagogical knowledge of physics teachers, who then serve as local experts on the use of technology in teaching and learning science. Science, and physics in particular, is a content area for which students need to learn how to use computers as a scientific tool for observation, data acquisition, analysis, and problem solving. Teachers are trained to support technology-based learning in up to 8 weeks of intensive Modeling Workshops conducted over two summers, and with ongoing year-round electronic network support. Teachers are thus engaged in a complete revamping of high school physics to incorporate both technology and the insights of educational research in full accord with the National Science Education Standards. The training provides them with a robust new teaching methodology that greatly increases students' understanding of basic physics.

In the Modeling Workshops, participants are introduced to modeling as a systematic approach to the design of curriculum and instruction. Teachers identify a small number of models around which to base their physics course and learn strategies to help students develop those models. They collaborate on the redesign of the high school physics course to enhance learning and employ technology to achieve their goals. They learn how to use computers as an integral part of their teaching practice. They implement a student-centered instructional strategy which engages students in active scientific inquiry, discourse, and evaluation of evidence. Further, they examine the implications of educational research for physics teaching. They do all this while immersed in studying the content of the entire year, which also provides extensive remediation for underprepared teachers.

The participating teachers then become leaders at their schools, modeling the best use of technology in the science classroom, training and assisting other teachers in the scientific use of technology in instruction, and advising schools on cost-effective infusion of technology into all science courses. These leaders must remain practicing science teachers, not simply technology specialists, because effective instruction in the use of computers as scientific tools requires special competence in pedagogy and science as well as in technology.

## PROGRAM COSTS

For cost information, please contact program designee.

*Note: Modeling Instruction in High School Physics was designated exemplary by the U.S. Department of Education's Mathematics and Science Education Expert Panel, 2000.*

## QUALITY AND EDUCATIONAL SIGNIFICANCE

### LEARNING

Teachers learn to

- organize course content around a small set of basic models as the content core of physics;
- engage students collaboratively in making and using models to describe, explain, predict, design, and control physical phenomena;
- involve students in using computers as scientific tools for collecting, organizing, analyzing, visualizing, and modeling real data;
- provide students with basic conceptual tools for modeling physical objects and processes, especially mathematical, graphical, and diagrammatic representations;
- show how scientific knowledge is validated by engaging students in evaluating scientific models through comparison with empirical data;
- assess student understanding in more meaningful ways and experiment with more authentic means of assessment;
- improve continuously and update instruction with new software, curriculum materials and insights from educational research; and
- work collaboratively in action research teams to mutually improve their teaching practice.

For example, in one experiment, students are asked to develop principles for the motion of a pendulum. With the teacher as recorder, students brainstorm about properties of the pendulum which might affect its period. After compiling the list, teacher and students decide which properties should be investigated. In this example, they determine to investigate how changes in mass of bob, length of string, and amplitude of motion affect the period. Students then work in teams and determine their own procedure for collecting data. After collecting data, they plot variables appropriately and then elicit the equations of motion and relationships among the variables. Then, using a technique called “whiteboarding,” groups present the results of their experiments to the class. At the end of this process, the class can agree on an appropriate model to describe the behavior of the pendulum. They do this without being given the answer by a text or a teacher.

Students learn to understand scientific claims and to make sense of their experiments themselves. They must articulate coherent opinions of their own, defending their findings in a variety of formats, using concise English sentences, graphs and/or diagrams, and through algebraic expressions of the relationship. Students are forced to reflect on why they choose an answer and how they evaluate evidence.

### USEFULNESS TO OTHERS

The Modeling Instruction Project has demonstrated its adaptability for use in multiple contexts. It began with pilot workshops in Arizona, where it has flourished for the past decade in two dozen urban, suburban, and rural high schools. It is now used in 44 states in diverse schools, including impoverished urban public and exclusive private preparatory high schools. Its practitioners include experienced high school physics teachers with exceptional qualifications and motivation as well as underprepared teachers who were drafted into teaching physics. More than half of the physics teachers in Arizona have learned Modeling Instruction, and the project’s approach is making inroads in several other states.

### FOR FURTHER INFORMATION, CONTACT:

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## EXCELLENCE FOR ALL

The project developed three new evaluation instruments and found that the program increases the achievement of underserved learners. For example, 36 Phase 1 teachers (teachers who had participated in one summer workshop) were found to fall into one of two groups: those implementing all aspects of Modeling Instruction consistently (17 teachers), and those implementing some aspects of modeling consistently (19 teachers). In disadvantaged/lower income schools, the mean FCI gains of the 93 students of the 2 teachers who implemented the Modeling Method consistently were 25 percent higher than for the 335 students of the 6 teachers who were implementing less modeling. Students of both groups did better than those in traditional courses; the FCI gains of the 93 students were double that of students under traditional instruction, and the FCI gains of the 335 students were 50 percent higher than those under traditional instruction.

Many teachers, including inner-city teachers, report that their enrollments have increased since they started using the Modeling Method.

## ORGANIZATIONAL CHANGE

Graduates of Modeling Workshops are in great demand in their schools to assist in incorporating technology in other science and math courses. In consequence of its well-documented success, the project has stimulated formation of the Arizona Science and Technology Education Partnership (AzSTEP), which is institutionalizing the reforms and methods of the Modeling Workshops in a statewide program for professional development of in-service physics teachers as local leaders of science teaching reform. AzSTEP is an exemplar of a university-high school partnership to drive sustained reform of science teaching with technology.

## EVIDENCE OF EFFECTIVENESS

An internal evaluation of data from 1995–1999 utilized a pre/posttest comparison design with matched students on the Force Concept Inventory (FCI) test, a test used to determine the effectiveness of mechanics courses in teaching students to reliably discriminate between the applicability of scientific concepts and naïve alternatives in common physical situations. The nationwide sample contained approximately 10,000 high school physics students involved in the program. The comparison groups consisted of approximately 8,000 high school physics students of the same teachers in the year before the teachers began the Modeling Workshop series and 700 high school students of teachers in traditional courses. Results indicate that Modeling Instruction students demonstrate greater gains on the FCI than comparison students. In the nationwide sample of students, the average FCI pretest score was approximately 26 percent, slightly above the random guessing level of 20 percent. Students of traditional high school instruction (lecture, demonstration, and standard laboratory activities) achieved an average posttest score of about 42 percent. In contrast, Modeling Instruction students recorded posttest FCI scores of approximately 53 percent when the teacher was in her first year of the program and an average of 69 percent when the teacher was an expert teacher with 2 years of modeling experience.

An external evaluation utilizing classroom observation of teacher training workshops determined that there was “overwhelming and consistent support” for this teaching approach. In interviews, participants reported that the workshops were well run and that the facilitators were extremely knowledgeable about how best to teach physics. They also commented that the group itself was an excellent resource as they could all help each other.