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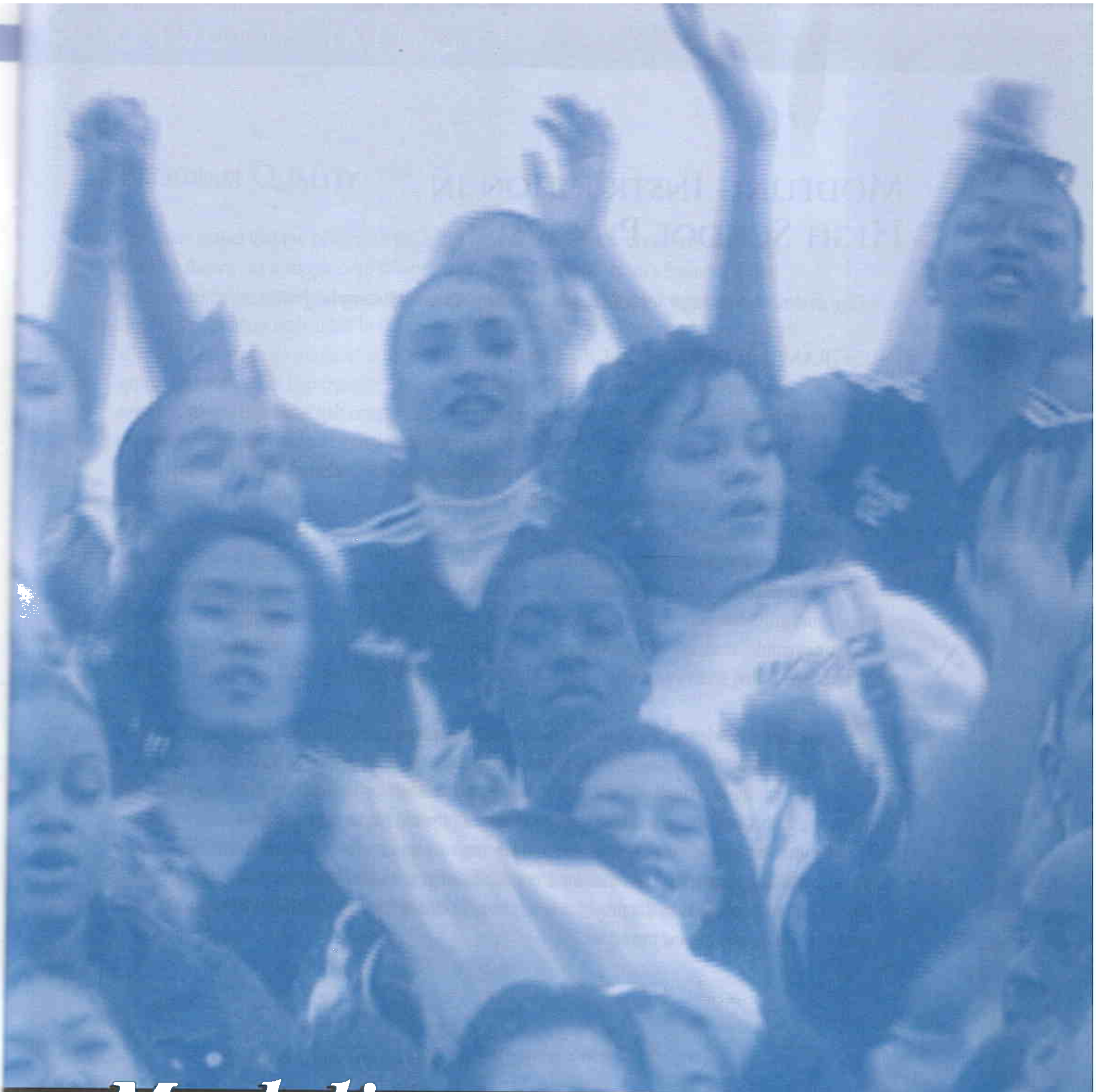

EXEMPLARY PROGRA

Modeling Instruction in High School PHYSICS

Modeling Instruction in High School Physics

Modeling Instruction in High School Physics is designated as an **Exemplary** science program.

Program Description

Modeling Instruction in High School Physics is grounded on the thesis that scientific activity is centered on modeling: the construction, validation, and application of conceptual models to understand and organize the physical world. The program uses computer models and modeling to develop the content and pedagogical knowledge of high school physics teachers and train them to be leaders in science teaching reform and technology infusion in their schools and districts. The program relies heavily on professional development workshops to equip teachers with a teaching methodology. Teachers are trained to develop student abilities to make sense of physical experience, understand scientific claims, articulate coherent opinions of their own, and evaluate evidence in support of justified belief. For example, students analyze systems using graphical models, mathematical models, and pictorial diagrams called system schema.

Teachers use their knowledge of the modeling method to construct and evaluate instructional units of their own design and from standard curriculum materials. More specifically, teachers learn to organize course content around scientific models; 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; and continuously improve and update instruction with new software, curriculum materials, and insights from educational research. Instructional materials developed and disseminated in the project are ancillary to disseminating a flexible teaching methodology adaptable to new materials.

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Professional Development Resources and Program Costs

High school physics teachers attend a series of intensive workshops over 2 years. Most participants proceed to share their new pedagogical insights and techniques with colleagues, and many commit to conducting modeling workshops. The project plans to sustain and extend science teaching reforms instigated by the workshops through the development of local infrastructures to support the continued professional development of teachers. Regional Science and Technology Education Partnerships (STEPs) are planned between university physics departments and local physics teacher alliances. Foundations for statewide partnerships already have been established in Arizona and Wisconsin.

The cost for an individual teacher to implement the mechanics modeling program includes tuition for a 4-week summer workshop, $120 for instructional materials, and travel/room/meal expenses. For a group of school districts to implement the mechanics modeling program for 24 physics teachers, minimal workshop costs include fees of $5,000 x 2 master teacher-leaders and $120 x 24 teachers for instructional materials. Implementation of mechanics in the classroom is best accomplished with computers that have universal laboratory interface (ULI) and three microcomputer-based laboratory (MBL) probes: motion detector, pair of photogates, and force probe. Typical cost of one workstation is $2,000. One computer for every three students is recommended.

Program Quality

Reviewers stated that the program's goals are explicit and reflect current research on learning theory. As a supplement to any physics course, the program's learning goals include reinforcement of the most important concepts with the study of mechanics. The physics content embedded in the units is fundamental to mechanics, physics, and all science. The program's content is aligned with its stated goals, and the instructional approach emphasizes important mechanics problems in depth. *Modeling Instruction in High School Physics* utilizes experimental design, control of variables, and calls for reasoning and application of skills in solving various kinematics and dynamics problems. There is strong use of student discourse, as evidenced by the need for students to present and justify conclusions derived in the laboratory. Multiple strategies for problem-solving are encouraged, reflecting sensitivity to individual student differences and abilities. The program contains a rich, integral system of assessment that is one of its strongest features, and the multiple modalities it employs provide teachers with ample entry points into the students' learning processes.

Program Effectiveness and Success

Reviewers found that the program provided extensive and persuasive evidence of gains in student understanding of science and in inquiry, reasoning, and problem-solving skills. Data also confirmed that an important factor in student learning is the degree of implementation by teachers of modeling methods learned in the workshops. There were repeated findings that greater degrees of program implementation of the modeling methods were associated with larger student gains. Reviewers commented that these repeated findings negated the possibility that student improvements might be attributable to more motivated teachers.

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For Further Information Contact:

Jane C. Jackson
Department of Physics and Astronomy
Arizona State University
Box 871504
Physical Sciences Center, Room F470
Tempe, AZ 85287–1504

Telephone: (480) 965–8438
Fax: (480) 965–7331

E-mail: Jane.Jackson@asu.edu

Web Site: http://modeling.la.asu.edu/modeling.html

Usefulness to Othe

Reviewers noted that many a
the teaching methodology ca
cessfully transferred to other
The program offers a wide
teacher support, including inf
on laboratory, extension, ap
and deployment activities.
gram recommends teacher t
8 weeks over 2 summers t
plish pedagogical transform
a large infusion of equipn
technology in the classroon
school districts may need
external aid to meet the co
program.

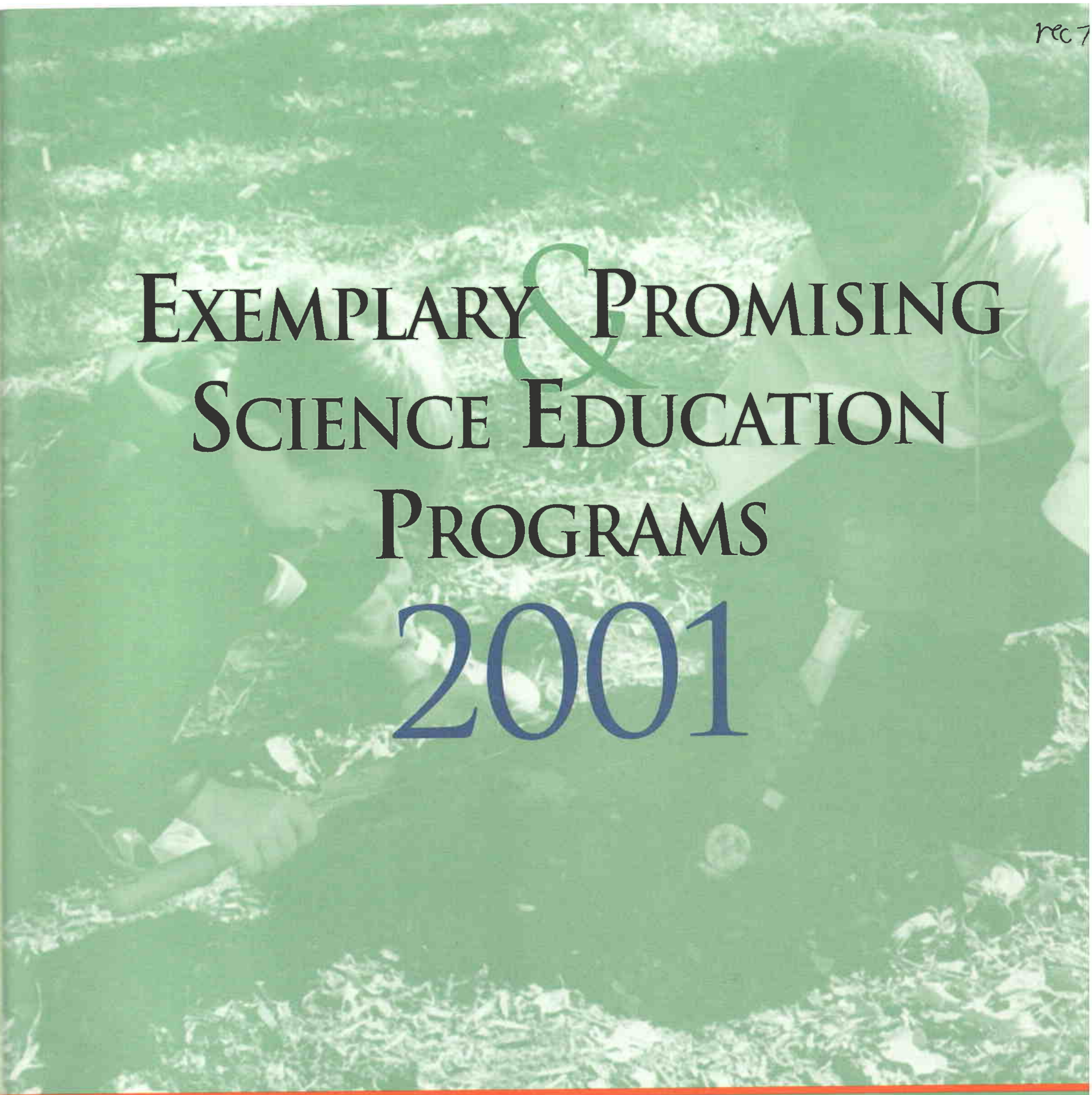
Educational Signi

The goals of the program str
ror the vision promoted in th
science standards. Reviewe
sized that the program is im
its awareness of and attent
national content, teaching, a
ment standards. The p
exceptional in its mode
emphasis on the skills, atti
values of scientific inquiry. I
important individual an
needs by providing constru
agogy for the fundamental
that are crucial to underst
physical world.

The program presented numerous evaluations that utilized a pre-post measure, Force Concept Inventory (FCI), on large numbers of both treatment and matched comparison groups; were carried out in multiple sites during several years; and made empirical connections between implementation of the approach and results. Sample sizes varied from year to year, with most final merged datasets ranging in size from about 1,300 students and 50 teachers, for Phase I 1995–97 data collection, to over 3,000 students and 70–80 teachers for the larger number of participants in Phase IIa 1997–98 and Phase IIb 1998–99 data collection. Student data came from three major high school course types: regular and introductory physics, honors level physics, and advanced placement physics.

The FCI instrument has high reliability and was developed to assess the effectiveness of introductory physics instruction, specifically the effectiveness of mechanics courses to teach students to reliably discriminate between the applicability of scientific concepts and naive alternatives in common physical situations. FCI data on 24,000 students in courses of hundreds of high school, college, and university teachers indicated that students' naive beliefs about motion and force are little changed when using traditional instructional methods, while greater changes can be achieved with instructional methods derived from modeling.

Repeated findings demonstrated greater gains for program students in physics content knowledge when compared to physics students of the same teachers in the year before the teachers implemented the program and students in traditional physics classes and alternative reform programs. The *Modeling Instruction in High School Physics* students exceeded the performance of the comparison groups by margins that in some cases exceeded two standard deviations.



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