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Teachers in rural states tend to be isolated and do not have easy access to professional-development opportunities. Some teachers in rural areas of my state generally drive four hours or more to attend a workshop. Opportunities to participate in high-quality, subject-specific professional development as envisioned by the National Science Education Standards (NSES) are nonexistent without enduring considerable hardship and personal sacrifice. To respond to these needs, a partnership between Fort Hays State University and Emporia State University was developed. The collaborative effort resulted in a unique professional-development institute that can be emulated by other states interested in improving inquiry- and modeling-based instruction.

Fort Hays State University and Emporia State University partnered with high-needs school districts to develop and offer a three-year professional-development institute. The statewide institute was planned collaboratively to specifically meet the needs of middle school science teachers. The institute was managed concurrently at the two sites and coordinated through distance-education technologies, making it possible for teachers to participate at an institution near their homes.

The main purpose of the workshop was to prepare teachers to implement a modeling, pedagogical approach developed at Arizona State University (ASU) in order to improve the teaching and learning of high school physics (see Resources) (Hestenes 1987). Extensive research supports the effectiveness of the modeling approach in enhancing student learning. In comparison to traditional instruction, modeling-instruction students average about 1.5 standard deviations higher on standard in-

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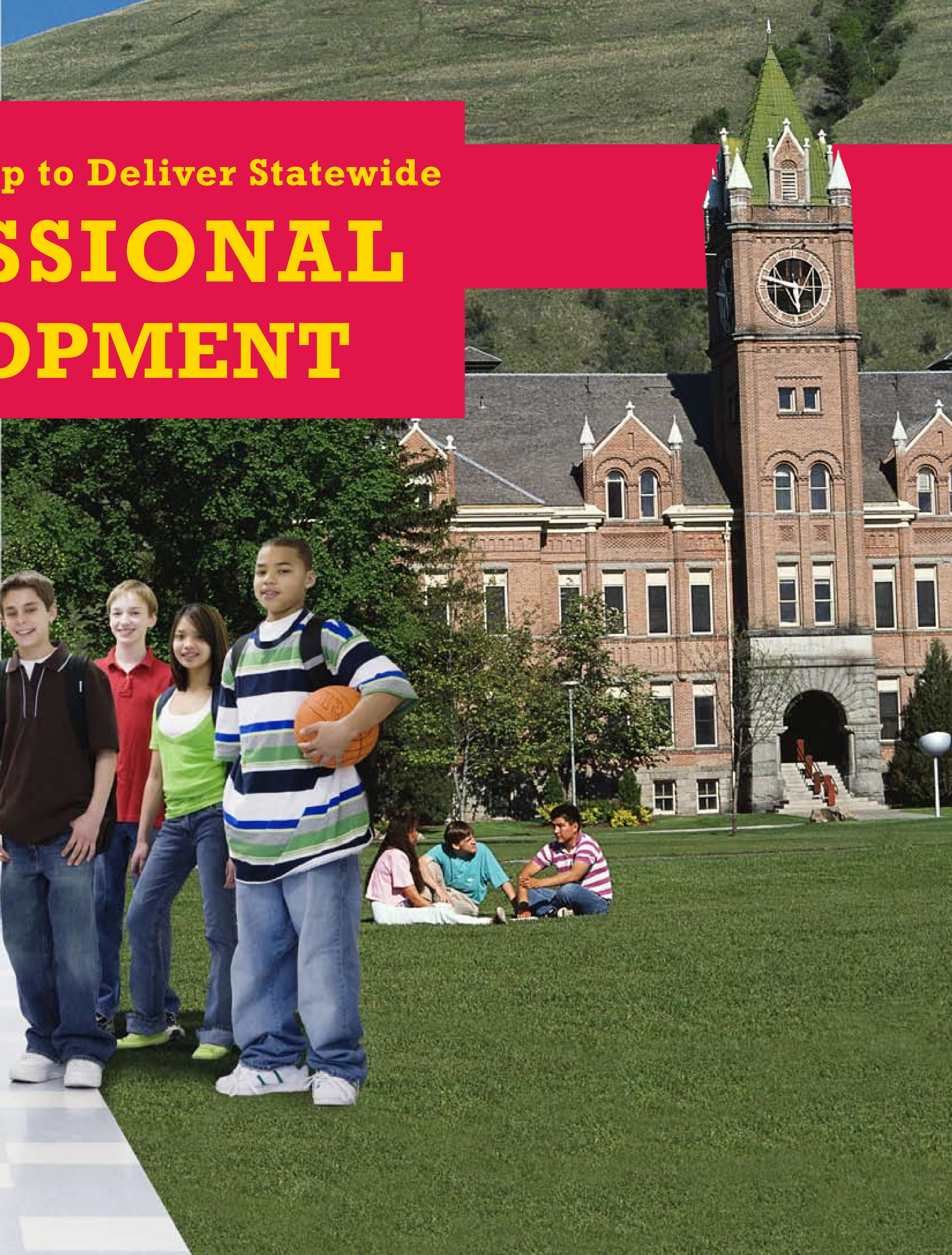

struments for assessing conceptual understanding of physics (ASU 2007). The United States Department of Education designated the modeling method in high school physics as one of two exemplary science education programs out of 27 programs submitted to the agency in 2001 (U.S. Department of Education 2001). Modeling also received recognition as one of the seven best education technology programs out of 134 programs for effective infusion and use of technology in 2000.

Institute design

The institute was designed in accordance with the National Science Education Standards for professional development. Each year's session featured the following components: a three-week summer institute, a one-day academic-year visit by an institute leader, and a one-day conference in the fall and spring.

Institute participants engaged in an intensive, three-week summer course for three summers. The first summer introduced participants to modeling instructional methods, achieved by using modeling physical-science materials developed at ASU. Using the modeling approach, participants implemented a student-centered learning environment in which content understanding is developed through an inquiry approach. During the second summer, participants were engaged in modeling chemistry activities. Because modeling chemistry units were not available for middle-level students, participants developed modeling unit plans during the summer. These units were tested with middle school students during the summer and again during the academic year in the participants' classrooms. The third summer focused on Earth and space science and utilized the same format as the second summer. Each summer the workshops were led by expert practicing educators with extensive experience using the modeling method. Peer instructors shared the practical aspects of using the modeling approach, and were assisted by content experts provided by the university at each site.

In early October of each year participants returned to the campus for a fall conference. Teachers met with project staff and peers to share their experiences and deepen their understanding of modeling instruction and operational knowledge of how students learn. Special content topics were also included to extend the learning. Teachers also received technological equipment provided through the project for use in their classrooms.

During the academic year, each participant was visited by an institute leader. The purpose of these visits was to assist with implementation of modeling instruction, evaluate the effectiveness of the institute in changing teacher practice, and garner administrative support for a non traditional instructional approach. The institute leader observed the teacher in the classroom and recorded the observations using the Expert Science Teaching Educational Evaluation Model (ESTEEM) observation rubric (Burry-Stock and Oxford 1994). These observations served as a formative assessment of the institute and were used annually to help improve the workshop pedagogical outcome.

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In April, a spring conference reconvened participants at the annual meeting of the Kansas Association for Teachers of Science (KATS). Participants presented the results of teaching their units for mutual information and review. Other KATS members were encouraged to participate in the presentations to learn about modeling instruction and the units developed by the participants.

The professional-development design met the NSES changing-emphasis conditions as illustrated in Figure 1. Some of the conditions were met during the summer workshop (in bold) while others were met in the follow-up activities during the academic year (in italics).

Concurrent workshops

The institute was planned and designed to have concurrent activities running at two sites. Each site was attended by 24 teachers. An agenda was planned and developed to frame the activities and learning experiences that participants engaged in on a daily basis during the summer. At the end of each day, project staff met via Internet Protocol Television (IPTV) to share their experiences and make modifications to the institute agenda. Modifications were made based on formative assessments and reflective journaling of the participants. The technology was used during the institute to share expertise and experiences between the sites, to enable synchronous collaboration among participants, and to coordinate workshop activities.

FIGURE 1 Professional-development design in alignment with NSES

Inquiry into teaching and learning
Learning science through investigation and inquiry
Integration of science and teaching knowledge
Integration of theory and practice in school settings
Collegial and collaborative learning
Long-term coherent plan
A variety of professional-development activities
Mix of external and internal expertise
Staff developers as facilitators, consultants, and planners
Teacher as intellectual, reflective practitioner
Teacher as producer of knowledge about learning
Teacher as leader
Teacher as a member of a collegial, professional community
Teacher as a leader and facilitator of change

Unit planning and testing

The primary purpose of the three-year institute was to improve teachers' content knowledge and their ability to teach middle school science. Obtained data indicate that the experiences in the project led to improved student learning. To measure gains in content knowledge by the teachers we used tests from the modeling program. While teachers' gains in content knowledge were important, the greatest concern was their ability to translate this knowledge, and the pedagogical coaching in modeling, into effective classroom practice. To accomplish this, teachers were assigned to teams to develop unit plans based on the modeling pedagogical approach while addressing the science content in the state standards. The teams were assigned topics to assure that the institute participants would have material available for use in their classrooms on the standards related to physical science, chemistry, and Earth and space science.

Coupled with the development of the units was the evaluation of the effectiveness as measured during action research performed by the development teams. During the academic year the teachers implemented the units and measured the effectiveness through pre/posttesting using assessments they developed as part of the units. Reflections on the outcomes were provided to help improve the unit in future revisions.

Internet Protocol Television (IPTV) connections

IPTV, a full-motion video/audio transmission broadcast through the internet, made it possible to communicate effectively between workshop sites in real time. Using this technology, several special events were shared between the two sites. A speaker could present a topic at one university and communicate with both workshop sites simultaneously. Other events also originated from a third site that was broadcast at both sites. The use of IPTV enriched the workshop experience by opening access to resources and opportunities that would not have been available at a single site.

Site visits by workshop staff

The use of the Expert Science Teaching Educational Evaluation Model (ESTEEM) observation rubric to assess the teaching of each workshop participant as well as the conceptual understanding of students in their classroom was integral in determining the effectiveness of the institute (Burry-Stock and Oxford 1994). ESTEEM was developed according to a combination of constructivist and expert teaching philosophy, and aligns with the professional-development section of the NSES. Further, the ESTEEM model emphasizes student-centered teaching that promotes meaningful, conceptual learning. The key benefit of the on-site visits was helping the institute staff identify the professional-development needs of the teachers for the follow-up conferences and next summer cycle. For example, several teachers seemed to lack understanding of some parts of the topic that they were teaching, resulting in less-than-optimal explanations to student questions and responses. Most of the observed teachers embraced the modeling method and applied it effectively. Students participated energetically and seemed to enjoy the method.

Conclusion

Each academic school year, teachers administered a pretest, developed by their team, to students in their classes prior to the modeling unit their team created. The teachers also administered a posttest, which was identical to the pretest, to students following the completion of the modeling unit. The test results showed a significant increase between the pretest and post-test at all levels. The teachers' recently acquired knowledge on modeling instruction culminated in improved instructional pedagogy, inquiry methods, critical and creative thinking, cooperative learning, and effective use of classroom technology, which ultimately impacted student learning.

The modeling-workshop implementation and evaluation project, viewed as a whole, indicated, through reflection and self-evaluation, that teachers found the modeling-workshop instructional strategies to be effective when making decisions on student learning and implications for future teaching of the unit. The use of technology and a collaborative partnership between institutions of higher education allowed the team to develop a statewide community of modeling learners. The approach is one that school districts and institutions of higher education should consider in addressing the needs in rural areas. ■

Acknowledgment

The professional-development institute, Physical Science with Mathematical Modeling Workshop, was supported by an Improving Teacher Quality Partnership grant administered by the Kansas Board of Regents. For more information on on how Fort Hays used the Modeling Instruction Program from Arizona State University, go to *www.fhsu.edu//scimathcenter/modeling.shtml*. Teachers who were unable to participate in the Fort Hays State University workshop can visit this site to reap the benefits of the sessions.

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Resources

Modeling Instruction Program—*http://modeling.asu.edu*

Teacher-developed units from the modeling institute—*www.fhsu.edu//scimathcenter/modeling.shtml*

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