

ROCK-SOLID SUPPORT

Florida district weighs effectiveness of science professional learning

By Linda Shear and William R. Penuel

The best science teachers are not only experts in teaching and knowledgeable about science content, but they are also great at teaching science. They have specialized teaching knowledge, including knowledge of effective pedagogical practices in science, student difficulties with understanding content, and curricular purposes (Ball & Bass, 2000; Hill, Rowan, & Ball, 2005). As a result, professional development that is both content-specific and anchored in what teachers must do in the classroom is becoming the norm for helping teachers improve their science instruction.

Less widespread is professional development that prepares teachers to design units of instruction for stu-



dents by using available materials or developing their own lessons. This may be in part because some education leaders and researchers do not believe teachers have sufficient skills and knowledge to design instruction for students, so they focus on preparing teachers to follow curriculum developed by subject-matter experts (Atkin & Black, 2003). But teachers inevitably do adapt curricula and programs to fit their classroom contexts.

In our work, we have found that content-specific professional development that prepares teachers for principled adaptation of curriculum has potential for improving student learning. Here, we describe the comparative teacher and student outcomes of three content-specific professional development programs that were tested in a school district in Florida. We also examined costs that districts may want to consider in selecting a professional development model to adopt.

THREE DISTRICT MODELS

With the goal of improving standards-based science instruction, Florida's Duval County Public Schools redeveloped its standards under a National Science Foundation grant. The district followed the curriculum design and teaching model called Understanding by Design (Wiggins & McTighe, 1998). This model promotes student learning goals related to the "big ideas" of a discipline. These learning goals, or "enduring understandings," drive the development of curriculum and link to another essential component of Understanding by Design: formative assessments that provide students and teachers with feedback on the depth of student understanding.

Following Understanding by Design principles, Duval County Public Schools organized the state standards for middle school science into nine-week segments designed to build a set of enduring understandings of the big ideas defined in the state standards. The district provided some related web-based materials to help teachers teach to these new standards. However, the district lacked resources to create content-focused professional development that would prepare the teachers to design units of instruction that were fully aligned with Understanding by Design. The district partnered with professional developers at TERC and the American Geological Institute to offer content-based professional development on Understanding by Design and with researchers at SRI International to study the impact of the professional development on teachers and students.

Those involved in the initiative tested three different programs, each of which put teachers in a different role relative to the science curriculum: teachers as designers, teachers as adopters, and teachers as intentional adapters of curriculum units. Each program included a two-week workshop over the summer and four days of follow-up support

METHODS USED TO EVALUATE THE THREE PROGRAMS

The researchers conducted a randomized experimental study of these three programs with a total of 39 6th-, 7th-, and 8th-grade teachers who were each assigned to one of the programs: Investigating Earth Systems, with teachers as adopters; Earth Science by Design, with teachers as designers; or the hybrid program, with teachers as adapters.

An additional 14 teachers, assigned to a control condition, did not participate in any district-sponsored professional development but were expected to teach to the same Understanding by Design-based content standards.

Each of the three professional development approaches in the study provided an equivalent duration of training and follow-up opportunities and were designed to be as similar as possible relative to commonly acknowledged characteristics of effective content-specific professional development, except for the teachers' expected role in unit design.

The study measured the impacts on student learning using a standards-based test of Earth science content developed for the study and measured the impacts on teaching using a combination of surveys, observations of classroom instruction, and analyses of teacher assignment quality.

during the school year. The three programs are described below.

Teachers as curriculum designers

Developed by TERC and American Geological Institute with funding from the National Science Foundation, Earth Science by Design applies the Understanding by Design curriculum development approach to earth science content at the middle school level. This approach is intended to help teachers be effective designers of students' earth science learning experiences, sequencing and organizing coherent units of instruction based on existing or teacher-developed curriculum materials. The two-week workshop that TERC organized and facilitated for the district's teachers addressed the nature of student understanding in science, design frameworks and processes, the "Earth as a system" approach to Earth science, the value and application of tools for scientific visualization (such as working with satellite data), and powerful formative assessment strategies. The workshop allotted time for teacher groups to begin designing their own unit of instruction, based on the essential questions and enduring understandings that they drafted and mapped to the revised standards. The follow-up professional development days in the fall and spring included time for mentoring, teacher presentations of their units, and shared analysis of results.

Costs by professional development model

Cost element	Examples	Cost by model		
		INVESTIGATING EARTH SYSTEMS (teachers as adopters)	EARTH SCIENCE BY DESIGN (teachers as designers)	HYBRID (teachers as adapters)
Teacher time	Teacher hours, substitutes	\$26,160	\$26,160	\$26,160
Training and coaching	Planning and delivery, district staff and contractors	\$28,320	\$5,912	\$15,692
Administration	District or school administrator time	Not applicable		
Materials, equipment, and facilities	Workbooks, binders, catering	\$32,750	\$1,732	\$34,574
Travel and transportation	Local travel; flights and expenses for contractors	\$6,912		\$2,423
Tuition and conference fees	Course tuition, registration costs	Not applicable		
Total		\$94,142	\$33,804	\$78,849

Teachers as adopters

Developed by the American Geological Institute with funding from the National Science Foundation, Investigating Earth Systems is a 10-module curriculum focused on five big ideas in Earth science. For Duval County Public Schools, the American Geological Institute worked with district educators to select the content modules that most closely aligned with Florida’s standards and prepared teachers to use those modules in their classes. The institute facilitated a two-week workshop that introduced inquiry-based science and the Earth systems approach as learning actively engaged teachers in the specific modules and content that they would be teaching. Follow-up training during the academic year provided mentoring and support for teachers and discussion of curriculum adaptations and outcomes in their classrooms.

Teachers as intentional adapters: The hybrid approach

The hybrid program combined elements from both Earth Science by Design and Investigating Earth Systems. In the two-week workshop, following the Earth Science by Design model, TERC facilitated discussions about the nature of science understanding, the Earth as a system approach, and frameworks and practices in the principled design of curriculum and assessments. Unlike Earth Science by Design, in which teachers assembled their units out of curriculum materials that they already had access to or that they developed, in the hybrid model teachers

worked with the same high-quality curriculum modules as their peers in the Investigating Earth Systems program and had time to adapt and sequence them to develop the units they would teach. As with the other two programs, the hybrid training included follow-up coaching and workshops during the year.

EFFECTIVENESS OF THE THREE MODELS

Both programs in which teachers received explicit instruction in how to design units following the Understanding by Design approach — Earth Science by Design and the hybrid program — had positive impacts on teaching and learning relative to the control group and the Investigating Earth Systems group. Data showed that teachers in both programs became more thoughtful planners of instruction, considering the enduring understandings that students should develop before considering what activities to implement. As a result of their participation, teachers in these programs were more likely to use strategies featured in the professional development for developing understanding, such as prompting students for explanations and interpretations, not just recall of facts. Furthermore, while teachers in the hybrid program were judged to use a higher-quality curriculum than their peers in Earth Science by Design, students of participating teachers in both programs outgained students in the Investigating Earth Systems and control classrooms on the standards-based test administered as part of the study. More detailed results of these studies are available both

in journal articles (e.g. Penuel, et al., 2009; Penuel & Gallagher, 2009) and in conference papers (e.g. Gallagher & Penuel, 2009).

COSTS, HIDDEN OR OTHERWISE

Effectiveness is just one part of the decision about adopting content-specific professional development programs in science. We conducted a cost analysis of the three programs (see chart on p. 50) using the framework of Odden and colleagues (Odden, Archibald, Fermanich, & Gallagher, 2002), which suggests common elements of total professional development costs.

The reported costs include actual costs for preparation, delivery, and follow-up for each program, adjusted slightly to standardize the number of participants. (Costs of curriculum, incentives, substitute time, and refreshments assume 15 participants per class.) They do not include initial development costs. The costs listed here parallel those that districts would incur if they purchased each type of program as an existing package. Investigating Earth Systems and the hybrid model were led by outside consultants, and the Earth Science by Design program, which operates on a train-the-trainer model, was led by two previously trained district professional developers. The consultants cost more, but hidden in the breakdown is the initial cost of developing district capacity for training.

Although Earth Science by Design and the hybrid program both produced strong instructional planning and student outcomes, the hybrid program appears to be substantially more expensive (\$78,849 vs. \$33,804). The significantly higher cost of the hybrid program, however, includes the cost of purchasing the Investigating Earth Science curriculum. The Earth Science by Design program did not require new curriculum materials, but districts adopting this program may wish to consider replacing their textbooks or curriculum to reflect the learning goals they seek to promote. Districts will need to consider the cost of purchasing appropriate curricula as they make decisions about the most appropriate professional development.

A substantial hidden cost is that of teacher attrition. In science, 8% to 9% of all teachers in the United States leave the profession each year, and another 7% to 8% move to another school (Ingersoll, 2003). When a teacher leaves the district or school or even changes assignment within the school, district investments in developing that teacher's knowledge of how to teach the subject matter are lost.

IMPLICATIONS

This study suggests the value of content-based professional development programs that train teachers in principled design of curriculum units, with strong and coherent science curricula they can use as building blocks. Extended professional development workshops that blend content, curriculum, and pedagogy, accompanied by opportunities for further support and coaching during the school year, can significantly increase the quality of the science education experience that teachers can of-

fer students and the depth of student learning that results. Important financial considerations include not just the cost of instruction but also of curricula, and attention to conditions that promote teacher retention as a way to maximize return on staff development dollars.

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