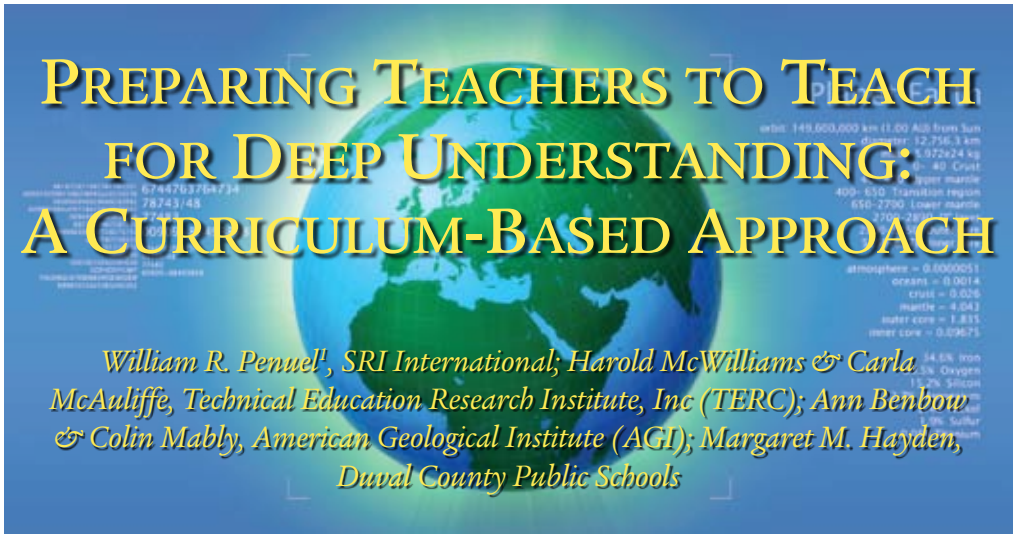

Preparing Teachers to Teach for Deep Understanding: A Curriculum-Based Approach

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Abstract

A central goal of most professional development in Earth science is to help teachers prepare their students to develop a deep understanding of subject matter. In this article, we describe an approach that accomplishes this goal by preparing teachers to use a principled approach to adapting high-quality curriculum materials for middle-school Earth science units. This approach integrates training in how to use AGI's *Investigating Earth Systems* curriculum with TERC's *Earth Science by Design* program to help teachers become better designers of curriculum. Evidence from a randomized controlled trial indicates the approach is effective in improving the quality of teachers' assignments and in improving student achievement. From district staff's point of view, the program is effective because it prepares teachers to become critical consumers of curriculum materials.

Introduction

An enduring challenge in Earth system science education has been to prepare teachers to teach for deep understanding of subject matter. Standards and trade textbooks are often too broad to allow for in-depth treatment of specific topics, and many teachers have had limited exposure to how to plan instruction for the core concepts of Earth system science they are expected to teach. High-quality curriculum materials do exist that provide young people with opportunities to explore concepts in depth and to experience the inquiry process. At the same time, few programs provide teachers with the necessary skills and knowledge to enact and adapt those materials to the unique circumstances of their classrooms and schools.

Our interdisciplinary team of curriculum and staff developers, researchers, and district personnel developed a program focused on preparing teachers to use a principled approach to curriculum adaptation in Earth system science. In this program, teachers learned how to use the *Understanding by Design (UbD)* approach developed by Grant Wiggins and Jay McTighe to organize and adapt materials from an expert-designed curriculum. As part of the program, teachers learn to select or modify materials from the curriculum based on how likely the materials are to develop so-called "enduring understandings" of concepts in the district's standards. Teachers also learn how to apply the approach in incorporating materials from other sources besides the expert-designed curriculum, which can include their textbook

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and materials they design on their own or with colleagues. Third, teachers learn how to collect and interpret evidence of student understanding by designing or adapting performance tasks that call for students to apply knowledge acquired during the unit to solve a problem or complete a project.

Core Components of the Program

Training in how to implement an expert-designed curriculum is one of two core components of the professional development program. *Investigating Earth Systems* (*IES*) is a 10-module middle school curriculum, funded by the National Science Foundation (NSF) and developed by the American Geological Institute (AGI). This inquiry-based Earth system science curriculum consists of a student edition with content and investigations, a teacher's edition with science background and supports for instruction and assessment, and online teaching resources. Just as this program follows a UbD approach, *IES* itself followed the principles of *UbD*, in that it is based upon five "big ideas" in Earth system science, which students revisit continually throughout each module. A team of curriculum developers, scientists and teachers developed, pilot tested, and field tested the materials over three years. *IES* was published by It's About Time/Herff Jones Publishing in 2001, and has been widely adopted in the U.S. by such major school districts as Chicago, Denver, and Las Vegas. A special edition was adopted by the state of California. Its modules include Climate and Weather, Energy Resources, Materials and Minerals, Rocks and Landforms, Water as a Resource, Dynamic Planet, Fossils, Oceans, Soil, and Astronomy. The IES web site is http://www.agiweb.org/ies/.

The second core component is the *Earth Science by Design* (ESBD) program, developed at the Technical Education Research Centers, Inc (TERC) with funding from NSF. *ESBD* is a yearlong professional development program in which teachers learn how to reorganize curricular units according to the principles of *UbD*. Core aspects of the *ESBD* program include (1) becoming aware of research on misconceptions in science (2) developing assessment strategies and instruments to measure student understanding, (3) using reflection to understand and improve teaching, and (4) learning to evaluate and incorporate scientific visualizations into the teaching of Earth science. In creating *ESBD* units, teachers can use any materials they wish, including materials from their textbooks and materials they or their colleagues have developed, again provided the materials align to their unit goals. With funding from NSF, the ESBD project has produced a handbook (http://www.esbd.org/resources/ESBDBOOK.pdf) for staff developers wishing to implement the program in their school or district.

A Hybrid Approach: How the Program Integrates IES and ESBD

The content of what we have called our hybrid approach to professional development blends content of workshops designed to prepare teachers to implement *IES* with the *ESBD* program of professional development (see Figure 1). Like the teachers in the *ESBD* program, teachers in the hybrid approach engage in activities and discussions to consider the nature of understanding, to struggle with what is worthy of understanding, and to begin to understand the "Earth as a system" approach to Earth system science. They also learn the UbD approach to unit design and practice constructing a unit, just as teachers in the *ESBD* program do, using an online unit planner developed for the *ESBD* program. Like *ESBD* teachers, Hybrid teachers also gain practice with developing assessments of student learning. But unlike *ESBD* teachers, teachers in this hybrid approach make use of *IES* modules aligned to their grade level in constructing their units. Teachers are encouraged to use at least half of the materials in the modules in those units.

FIGURE 1. Core Components of the Hybrid Approach

A unique feature of the hybrid program is that throughout, *UbD* concepts underlying the design of the IES materials are emphasized. For example, on day 3 of the workshop, staff developers introduce the idea of "essential questions" (part of the UbD framework and the *ESBD* Summer Institute Guide). Teachers work in groups of four to brainstorm essential questions. In addition to creating their own "essential questions," that is, questions designed to guide the class's thinking and inquiry throughout the unit, teachers recorded the key questions from an *IES* module into their brainstorming work. After reviewing the candidate essential questions, each group selected four to incorporate into their sample unit.

Teachers have plenty of time for hands on practice and for completing their unit plans as part of an initial two-week workshop. The first week consists of activities such as those described above, and during the second week of the summer workshop, teachers had time to craft their units, with mentoring from one of the three facilitator leaders. In general, they worked on their units in the mornings and in the afternoons engaged in hands-on investigations from the IES modules in order to familiarize themselves with these activities. They were able to ask questions of the IES facilitator and to become familiar with activities that they might wish to incorporate into their units. Approximately 45 minutes were set aside each afternoon for whole-group discussion of progress, problems, ideas, and issues that were emerging.

Finally, as part of the initial workshop, local district personnel and staff developers work together to map district and state standards to the enduring understandings and essential questions for their units. In this activity, staff developers emphasize that teachers should not start with the standards but rather make sure that their goals for students were aligned with the standards. In addition, teachers work in small groups on their units, collaborating with other teachers who had responsibility for teaching the same standards that they did.

During the year following the initial workshop, teachers participate in 2 days of follow-up professional development in the fall and 3 days of follow-up in the spring. Both workshops provide time for teachers to refine their unit plans and discuss how enactment of their units is going. In spring, 2 of the days include a spring conference in which teachers give presentations about their units. In addition, teachers receive mentoring from district staff during the school year, which consists of help obtaining teaching materials and kits and help with the design of their units.

Evidence for the Hybrid Approach's Success

Our team has been studying the impacts of this hybrid approach on teachers' instructional planning, curriculum enactment, and student achievement as part of a randomized controlled trial funded by the Institute of Education Sciences at the U.S. Department of Education. Evidence from the first year of the study indicates that the hybrid approach developed for the study is more effective than *IES or ESBD* alone and than the control group in all three areas of potential impact. Teachers who

participated in the hybrid approach made significant changes to how they went about planning their Earth science units, giving more weight to whether activities they chose directly addressed a big idea in the field. Teachers who participated in the hybrid approach produced higher quality assignments than teachers assigned to the control group or to the *ESBD* program, and those assignments were more likely to provide students with encounters of how Earth system science is really done. In addition, students of teachers in the hybrid group scored significantly higher than either control group students or students whose teachers received *IES* training on a standards-based test of Earth science knowledge. From the school district's point of view, the success of the hybrid approach is due to the fact that it helps teachers to become critical consumers of curriculum materials and to plan better instruction with inquiry-based materials.

Not all programs will be able to provide all of the resources and experiences we provided to teachers as part of our research project, but the evidence from the research study suggests it is essential to think about curriculum and professional development as part of a single, coherent program. Expert-designed curricula provide excellent material for teachers to use to promote student inquiry in ways that trade textbooks rarely do. At the same time, teachers need to be able to adapt those materials to local circumstances, and they need tools to guide them in adapting materials in ways that are congruent with designers' goals and that help them address local standards that may not be covered in the materials. We believe this hybrid approach is not only promising but essential for effective professional development in Earth system science education.