

X.16 Hydrogen Technology and Energy Curriculum (HyTEC)

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Schatz Energy Research Center,
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Objectives

- Develop, field test, revise, publish, and disseminate three curriculum modules and integrate hydrogen and fuel cells into existing LHS high school materials.
- Develop and implement a professional development plan for teachers who will use the materials.
- Develop a model for collaboration among school districts, informal science centers, university scientists, local transportation agencies, and other leaders in the field.
- Disseminate the materials to a broad national audience.
- Evaluate the quality and effectiveness of the curriculum materials and professional development strategies.

Technical Barriers

This project addresses the following technical barriers from the Education section (3.9.5) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- (A) Lack of Readily Available, Objective, and Technically Accurate Information
- (C) Disconnect between Hydrogen Information and Dissemination Networks
- (D) Lack of Educated Trainers and Training Opportunities
- (E) Regional Differences
- (F) Difficulty of Measuring Success

Contribution to Achievement of DOE Education Milestones

This project will contribute to achievement of the following DOE milestones from the Education section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 26:** Develop modules for high schools. (4Q, 2007)
- **Milestone 27:** Launch high school teacher professional development. (4Q, 2008 through 3Q, 2011)

Accomplishments

- The complete curriculum module was nationally field tested during the 2008–2009 school year by 13 teachers in diverse public, parochial, and alternative high schools in the San Francisco East Bay, California; Bellevue, Washington; and Dublin, Ohio. Input from these classrooms led to additional revisions in June 2009.
- A three-day professional development workshop was delivered to a total of 19 high school teachers in June 2009. The workshop was held at Lawrence Berkeley National Laboratory, in collaboration with their Center for Science and Engineering Education.
- Four presentations were made to secondary science educators and hydrogen and fuel cell professionals.
- The project entered into a contractual agreement with Lab-Aids, Inc., which has produced prototype kit components for testing and will commercialize the print and kit materials.



Introduction

This project is producing a curriculum module about hydrogen and fuel cells for high school students. A group of experienced science curriculum developers,

teacher professional developers, leaders in the field of hydrogen and fuel cell technology and its application to transportation, and the publishers of instructional materials are collaborating to develop commercial educational modules that will fit into high school courses such as physical science, chemistry, environmental science, and physics. In order to ensure that it will fit into typical high school classrooms, the module addresses topics teachers usually teach and correlates to the National Science Education Standards and/or state and local standards. This project is also developing professional development workshops to prepare teachers to teach the curriculum and develop teacher leaders. Project evaluation focuses on investigating students' progress toward the intended learning goals and evaluating the professional development workshops.

In the past year, a limited national field test was held in three sites in order to test the materials in a variety of locations and classroom settings. Teachers provided extensive feedback that has been used to fine-tune the curriculum and prepare for commercialization of the print and kit materials and revise the project website and Web-based simulation. In addition, 19 teachers received three days of professional development in order to prepare them to teach the curriculum in the coming school year.

Approach

The curriculum materials are developed and revised through a close collaboration between curriculum developers at the LHS, scientists and engineers at the Schatz Energy Research Center (SERC), experienced teacher associates, local and national field test teachers, and Lab-Aids, Inc., an established publisher of kit-based science curriculum materials. The materials are developed by LHS with input from SERC, and classroom-tested by the developers, then by expert teachers, and finally by a broader group of teachers from California and national sites. The module uses an issue-oriented approach to teaching concepts related to chemistry and energy topics. This approach teaches about hydrogen and fuel cells in the context of energy issues and demonstrates to students both the relevance of their science education to their lives and the role of scientists and engineers in solving practical problems.

Teachers who field-test the curriculum receive extensive professional development before they use the materials, and additional support as needed during use. This prepares the teachers to give thorough feedback on the curriculum and also informs future professional development activities. In addition, these early professional development workshops for field-test teachers help to identify teachers who will assist with dissemination and implementation of the published curriculum.

Results

The curriculum module addresses Education Technical Barriers A (Lack of Readily Available, Objective, and Technically Accurate Information) by providing information about hydrogen and fuel cells in a curriculum format that is usable by teachers and students in typical classrooms. The professional development work addresses Education Technical Barriers C (Disconnect between Hydrogen Information and Dissemination Networks) and D (Lack of Educated Trainers and Training Opportunities) by building on the dissemination networks of the LHS and partners and preparing teachers who will be able to provide professional development in their regions.

The national field-testing of the past year focused on Barrier E (Regional Differences), by testing the curriculum in a variety of settings. These included chemistry, physical science, physics, and environmental chemistry classrooms in parochial, public, and alternative high schools in urban and suburban settings. Many of the participating students were from populations under-represented in science, technology, engineering, and mathematics fields. Participating teachers included a mixture of those who had previously worked with the curriculum development team and those who had not, to ensure usability of the materials by a variety of teachers.

Thirteen teachers tested the two-week curriculum module with approximately 1,000 students in diverse high school classrooms in the San Francisco East Bay, California; Dublin, Ohio; and Bellevue, Washington during the 2008–2009 school year. While the majority of these students were in chemistry classes, participating classrooms also included physical science, physics, integrated science, and advanced placement environmental science. Figure 1 shows students in a San Francisco East Bay school that first used the curriculum during the past school year. In order to measure success (Barrier F), feedback was collected from participating teachers. Three teachers provided verbal feedback to the project via phone or face-to-face meetings, while 10 teachers completed an online feedback survey. The online survey includes questions about the curriculum module as a whole and about each of the six curriculum activities. Feedback was generally positive about the module, with many constructive suggestions for improving specific activities. For example, Figure 2 summarizes feedback on students' engagement with the module. All teachers indicated that they would teach the core activities of the module again. One or more teacher representatives from each location also participated in phone, email, or face-to-face meetings with the project staff to provide further input on the module. They also provided input on how to adapt the materials for diverse learners and for each of the five high school subjects in which it was taught.



FIGURE 1. High School Students Conduct a HyTEC Curriculum Activity

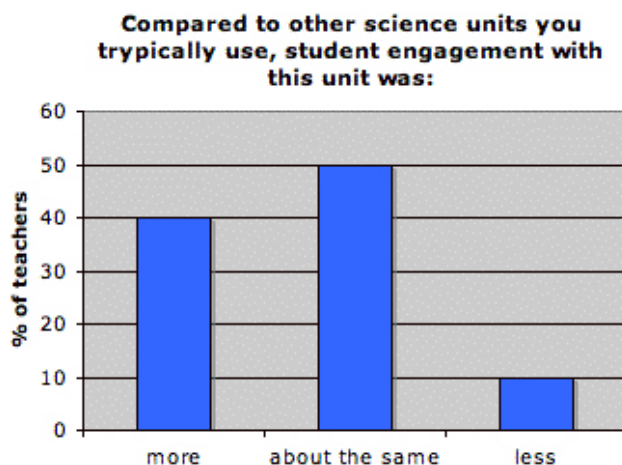


FIGURE 2. Teacher Survey Response: Student Engagement

A new group of teachers, representing additional national sites, will implement the curriculum in 2009–2010. In June 2009, these teachers joined a three-day professional development workshop conducted by project staff and held at the Lawrence Berkeley National Laboratory’s Center for Science and Engineering Education. The workshops address Education Technical Barriers C (Disconnect between Hydrogen Information and Dissemination Networks) and D (Lack of Educated Trainers and Training Opportunities) by providing teachers with an in-depth professional development experience on the science of hydrogen and fuel cells, applications of fuel cells, and the use of the curriculum. Nineteen participants from five states will help to address technical barrier E (Regional Differences), by providing feedback on the use of the curriculum in states and school districts that each have specific science standards and student demographics. Participants included five teachers from the Los Angeles area (Los

Angeles and Santa Ana school districts), four from the San Francisco East Bay (representing four districts), seven from Connecticut (representing five districts), and one each from Evans, Georgia; Columbia, South Carolina; and New York City (Bronx). These teachers work in a variety of schools, including technical and agricultural programs, comprehensive public and parochial schools, a magnet school, and a selective private school. Many of the participating schools are located near hydrogen demonstration projects and hope to connect the curriculum to local activity related to hydrogen and transportation. Several of the teachers will be sharing the curriculum and what they have learned with others in their schools and districts. As in last year’s workshops, participants conducted the curriculum activities and explored the equipment (see Figure 3), heard scientific presentations, participated in question and answer sessions with workshop leaders, and went on a half-day field trip to Alameda-Contra Costa Transit’s hydrogen bus facility. They were also given ample time to provide feedback and suggestions and to discuss with each other the design of the curriculum and how they will implement the activities to best meet the needs of their student populations. In the workshop evaluation, participants ranked aspects of the professional development workshop on a scale from 1 (not adequate) to 5 (excellent). The results of the workshop evaluation are presented in Table 1. The teachers’ comments about the workshop reflected the positive rankings, and included:

“Surpasses anything else I have done by far.”

“This was one of the best workshops I have attended.”

“This was *real* training with *real* people here to learn. Very encouraging.”

To the extent possible, teacher leaders working with the project will contribute to future state, regional, and national science teacher conference presentations.



FIGURE 3. Summer 2009 Teacher Professional Development

TABLE 1. Professional Development Evaluations

Aspect of conference	Score (out of 5)
Curriculum activities	4.7
Activity presentations	4.7
Scientific presentations	4.6
Field trip to AC Transit	4.3
Schedule	4.7
Conference arrangements	4.8
Comparison to other workshops*	4.7

*The question asked: Compared to other workshops and professional development sessions I have attended, overall I would rank this one as . . .

Commercialization of the kit has begun. In December 2008, the project entered into a contractual agreement with Lab-Aids, Inc., who will produce the print and kit materials and market and sell the final curriculum. Lab-Aids, Inc. is Science Education for Public Understanding Program's publisher, has extensive experience in the K-12 science curriculum field, and is well known to school districts and science teachers nationwide. To date, they have produced prototype student electrolyzer components, which are currently being tested by SERC.

Conclusions and Future Directions

Conclusions

- The instructional materials and kit can be used by high school teachers working in a variety of science subject areas (chemistry, physics, physical science, integrated science, and advanced placement environmental science) and with diverse student populations. Students and teachers continue to be enthusiastic about these materials.
- The professional development workshop provides teachers with scientific and technical background and experiences that prepare them to use the curriculum activities and equipment for classroom instruction. In evaluations of the workshop, a diverse group of teachers rated the workshop 4.7 out of 5 in comparison to other workshops and professional development sessions they have attended.
- The curriculum and kit are ready for final revisions and commercialization in the coming year. Development of a key equipment piece, the student electrolyzer, has begun with the development and testing of prototypes prepared by Lab-Aids, Inc.

Future work will focus on:

- Preparing the commercial version of the HyTEC module. This will involve collaboration with Lab-Aids, Inc. on professional editing and page composition of the print materials in addition to development of final kit components, such as a student electrolyzer developed for this project.
- Expanding work with new school districts, and strengthening collaborations with current districts when possible.
- Presenting the project at science teacher conventions. So far, sessions have been accepted or are pending for Fall 2009 state teacher conferences in California, Texas, New York, Connecticut, and the National Science Teachers Association Southwestern Regional Conference in Arizona. The project will also be presented at the Spring 2010 National Science Teachers Association National Convention in Philadelphia.

FY 2009 Publications/Presentations

- Nagle, B. and L. Whitehurst. "The Chemistry of Hydrogen Fuel Cells." California Science Teacher's Association Conference, October 31, 2008, San Jose, California.
- Nagle, B. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." National Science Teachers Association National Conference, March 20, 2009, New Orleans, Louisiana.
- Nagle, B. and J. Howarth. "Teach Chemistry with Hydrogen Fuel Cells." National Science Teachers Association National Conference, March 21, 2009, New Orleans, Louisiana.
- Zoellick, J. "HyTEC: "Introducing Hydrogen and Fuel Cells into High School Science Curriculum." National Hydrogen Association Conference, March 31, 2009, Columbia, South Carolina.