

## X.16 Hydrogen Technology and Energy Curriculum (HyTEC)

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### Objectives

- Develop, field test, revise, publish, and disseminate three curriculum modules and integrate hydrogen and fuel cells into existing Lawrence Hall of Science (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 Fuel Cell 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

### Contribution to Achievement of DOE Education Milestones

This project will contribute to achievement of the following DOE milestones from the Education section of the Fuel Cell 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

- Eleven new teachers piloted the module in their classrooms and provided feedback.
- The curriculum module manuscript was submitted to the publisher, LAB-AIDS, Inc. and professional editing is in progress.
- LAB-AIDS produced prototype electrolyzers for the student curriculum kit. These have been tested by LHS and SERC, and are undergoing further modification for the commercial kit.
- The materials were disseminated via 10 presentations to secondary science educators and hydrogen and fuel cell professionals.



### 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.

The past year focused on expanding implementation of the curriculum into new sites and preparing the curriculum and materials kit for commercial distribution.

## Approach

The curriculum materials are developed and revised through a close collaboration between curriculum developers at LHS, scientists and engineers at 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 local 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 two to three days of 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 assist with dissemination and implementation of the published curriculum.

Dissemination is conducted by presentations at science teacher education conferences and through the extensive networks of both LHS and LAB-AIDS, Inc.

## Results

The curriculum module addresses Education Technical Barrier 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 curriculum is developed by the Science Education for Public Understanding Program (SEPUP), a curriculum development group that produces issue-oriented science materials that avoid advocacy. The module is extensively reviewed for technical accuracy by scientists and engineers at SERC.

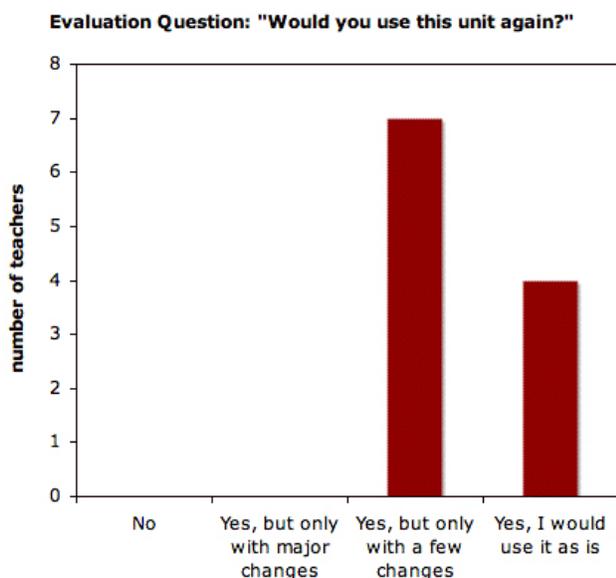
The professional development work addresses Education Technical Barriers C (Disconnect between Hydrogen Information and Dissemination Networks) and D (Lack of Educated Trainers and Training Opportunities) by building on the dissemination networks of the LHS and partners and preparing teachers who will be able to provide professional development in their regions. Teachers receive professional development in the unit content, teaching approaches, science of hydrogen and fuel cells, and fuel cell applications.

The expanded implementation during the past year addressed Barrier E (Regional Differences), by testing the curriculum in new locations and Barrier D (Lack of Educated Trainers) by providing professional development and implementation experience to teachers from school districts in these new locations. New teacher participants taught the curriculum to over 860 students in new sites in Connecticut, Georgia, New York, South Carolina, and Southern California. The classrooms using the materials in the past year included chemistry, physical science, physics, and environmental chemistry classrooms in public comprehensive, magnet, and alternative high schools in urban and suburban settings. In this final year of testing, most participating teachers had not previously worked with the SEPUP curriculum development group or SEPUP products, to ensure usability of the materials by a variety of teachers. Figure 1 shows two of the new teachers, from Georgia and Connecticut, who implemented the curriculum during the 2009–2010 school year.

An online survey was used to collect feedback on the curriculum and kit from the new participating teachers. Eleven teachers completed the survey, which includes questions about the curriculum module as a whole and about each of the six curriculum activities.



**FIGURE 1.** Teachers Trained in June 2009 Implemented the Module during the 2009–2010 School Year



**FIGURE 2.** Teacher Survey Responses: "Would you use this unit again?"

Feedback was generally positive about the module, with many constructive suggestions for improving specific activities. Figure 2 summarizes feedback on teachers' interest in using the module again. All teachers indicated that they would teach the core activities of the module again either as is or with minor changes. One teacher responded: "Using this kit is an excellent way to bring in the concepts of science and social responsibility. The concepts were challenging and thought provoking, but obtainable and relevant." Another wrote, "I really enjoyed the approach that was used to teach this unit." Several included in their written comments their hopes that their school will purchase the curriculum when commercially available.

Presentations at science teacher conferences reached over 240 teachers during the past year. In these one to two-hour presentations, teachers were introduced to the module, given background on fuel cells, and conducted an activity on the fuel cell reaction (Activity 4 from the module) that they were then given to take back to their classrooms and try out.

Commercialization of the module and accompanying kit is expected to take place this fall. The curriculum kit includes a student electrolyzer produced specifically for this project. LAB-AIDS has produced and modified prototype electrolyzers for the kit based on original prototypes developed by SERC, and LHS and SERC have tested these prototypes. Final modifications are currently being made to produce the commercial student electrolyzers. The manuscript for the module has been submitted to LAB-AIDS and professional editing is in progress.

## 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), in diverse settings, and with diverse student populations. Students and teachers continue to react positively to these materials. Over 860 students participated in the module in the past year.
- Presentations at nine national, state, and regional teacher workshops reached over 240 teachers. Reactions to these workshops were positive.

### Future work will focus on:

- Publishing and distributing the HyTEC module print and kit materials.
- Expanding work with new school districts, and strengthening collaborations with current districts.
- Reaching greater numbers of teachers by presenting the project at science teacher conventions and working with the publisher to disseminate the module. So far, sessions have been accepted or submitted for Fall 2010 teacher conferences in California, Connecticut, North Carolina, South Carolina, Texas, and the National Science Teachers Association Northeastern Regional Conference in Baltimore. The project will also be presented at the Spring 2011 National Science Teachers Association National Convention in San Francisco.
- Expanding professional development for teachers and implementation of the curriculum at existing and new sites. A conference to prepare a new group of teachers is planned for early 2011.
- Preparing additional student materials and teacher support materials for the project website.

## FY 2010 Publications/Presentations

1. Nagle, B. and E. Argenta. "Hydrogen and Fuel Cells." Connecticut Science Teacher's Association Conference, October 17, 2009, Hamden, Connecticut.
2. Nagle, B. "Teaching Chemistry with Hydrogen and Fuel Cells." California Science Teachers Association Conference, October 23, 2009, Palm Springs, California.
3. Keller, C. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." State Teachers Association of New York State Conference, November 3, 2009, Rochester, New York.
4. Nagle, B. "Teach Chemistry with Hydrogen and Fuel Cells." Texas Science Teachers Association Conference, November 7, 2009, Galveston, Texas.

5. Keller, C. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." National Science Teachers Association Regional Conference, December 5, 2009, Phoenix, Arizona.
6. Crawford, C. and D. Parker. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." Science Education Conference of Ohio. February 26, 2010.
7. Nagle, B. "Teaching Chemistry with Hydrogen and Fuel Cells." National Science Teachers Association National Conference, March 18, 2010, Philadelphia, Pennsylvania.
8. Nagle, B. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." National Science Teachers Association National Conference, March 18, 2010, Philadelphia, Pennsylvania.
9. Nagle, B. "HyTEC: Teaching High School Students and Teachers about Hydrogen and Fuel Cells." National Hydrogen Association Conference. May 4, 2010, Long Beach, California.
10. Nagle, B. and C. Keller. "Hydrogen Technology and Energy Curriculum (HyTEC)." Presentation to high school teachers at the Chabot Space & Science Center's Climate Change Institute. June 28, 2010.