IX.15 Hydrogen Technology and Energy Curriculum (HyTEC)

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Schatz Energy Research Center, Humboldt State University, Arcata, CA

Project Start Date: September 1, 2004
Project End Date: February 28, 2012

Fiscal Year (FY) 2011 Objectives

- Develop, field test, revise, publish, and complete a two-week curriculum module on hydrogen and fuel cells for high school students.
- 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)

FY 2011 Accomplishments

- Publication of the two-week high school curriculum that was the major goal of this project. The curriculum is titled "Investigating Alternative Energy: Hydrogen & Fuel Cells."
- Production of the kit that accompanies the module by LAB-AIDS, Inc.
- Redesign of the website that supports the curriculum.
- A two-day workshop for teacher professional development was held in February 2011.
- The materials were disseminated via 13 presentations to secondary science educators and hydrogen and fuel cell professionals and by display at the publisher's booth at many of these conferences.

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 publishers of instructional materials are collaborating to develop and produce this curriculum as a commercial educational module. The module is intended to fit into high school courses such as physical science, chemistry, environmental science, and physics. In order to ensure that it can be used in these courses, 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 evaluating the classroom usability of the curriculum module, students' progress toward the intended learning goals, and the effectiveness of the professional development workshops. The past years' work focused on completing, publishing,

and disseminating the curriculum module along with an equipment kit and support materials such as a digital video disk (DVD) and website.

Approach

The curriculum materials are developed and revised through a close collaboration between curriculum developers at the Lawrence Hall of Science (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 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 current and future options for powering vehicles. This approach also demonstrates to students both the relevance of their science education to their lives and the role of scientists and engineers in conducting research and development to solve practical problems.

Teachers who field-test the curriculum receive two to three days of professional development prior to using the curriculum and have access to additional support as needed during the field test. The professional development workshops prepare the teachers with content background and hands-on experience for teaching the curriculum and for providing thorough feedback on the curriculum. In addition, these early professional development workshops for field-test teachers help to identify teacher leaders who will assist with dissemination and implementation of the published curriculum.

Dissemination is conducted by presentations and displays of the materials 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 development of the curriculum was led by the Science Education for Public Understanding Program (SEPUP), a curriculum development group that produces issue-oriented science materials that avoid advocacy. Prior to the work that took place in the past year, the module was developed through four rounds of classroom testing and revision to ensure that it works well in a wide variety of high school settings, thus addressing barrier E (Regional Differences). At each stage of development, scientists and engineers at SERC reviewed the module for scientific and technical accuracy. Work during the past year focused on collaborating with the publisher, LAB-AIDS, Inc., and the editorial and design studio they hired to prepare the materials for publication. This involved reviewing all edits and page layouts through several iterations, and reviewing the final art that was prepared to our specifications. It also involved photo research and acquisition.

The module includes a two-week sequence of six activities that teach students about hydrogen and fuel cells. The module cover is shown in Figure 1. This cover features a photograph of the student laboratory equipment, screen shots of a simulation from the website that accompanies the curriculum, and a photograph of a hydrogen fuel cell bus provided by AC Transit. The print materials are accompanied by a kit, which includes the materials featured on the cover along with additional materials required for the laboratory and modeling activities in the curriculum module. A website provides additional material used in the module, including 1) videos of hydrogen fuel cell applications, 2) interactive computer simulations of the hydrogen fuel

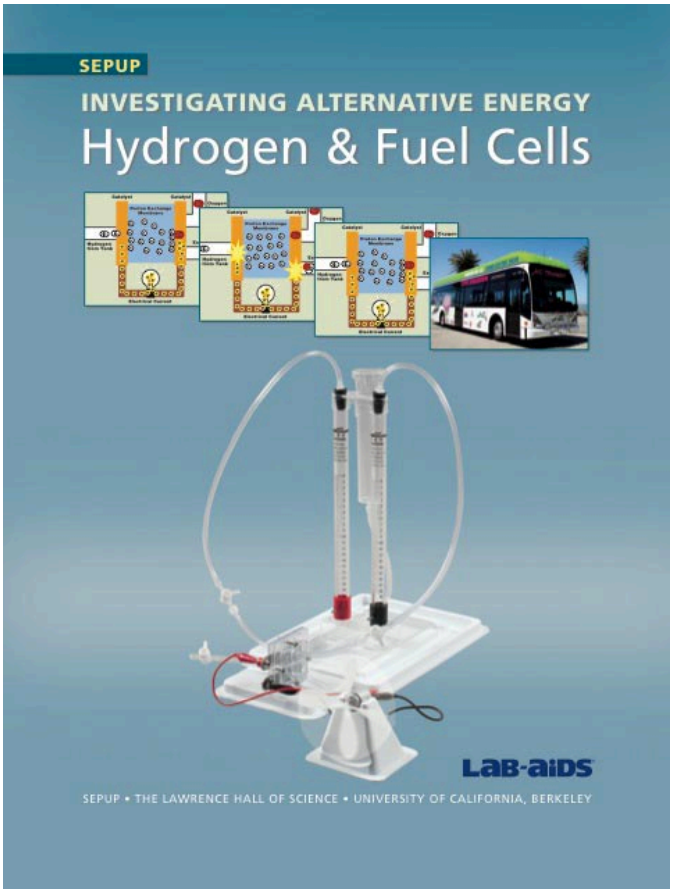

FIGURE 1. Cover of the Module – Investigating Alternative Energy: Hydrogen & Fuel Cells

cell reaction and the production of hydrogen in an alkaline electrolyzer, and 3) resources for the module's culminating activity. The video and simulations are also included on a DVD that is provided with the module, so teachers who have problems accessing the internet in their classrooms can use the DVD when teaching. The website also offers additional information about hydrogen and fuel cells for teachers, students, and the public. A pilot evaluation of student learning conducted with data collected from a sample of students during the module field-test yielded significant and educationally meaningful learning gains.

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. During the past year, one two-day professional development conference was held in Berkeley and attended by 13 teachers from Connecticut, northern and southern California, Ohio, South Carolina, and Texas. In an evaluation of the workshop, teachers gave very high ratings to all aspects of the workshop. Out of a possible high score of 5 points, teachers' average ratings were 4.73 for the curriculum, 5 for the activity presentations, and 4.85 in comparison with other professional development they have attended. Each participating teacher received a complete module and two sets of the classroom equipment.

Presentations at science teacher conferences reached over 220 teachers during the past year. These presentations targeted national and regional conferences plus conferences in states with significant fuel cell research and development and states known for good attendance at their science teacher conferences (see Figure 2). In these one to two-hour presentations, teachers were introduced to the module and information about fuel cells in the U.S. and their state,

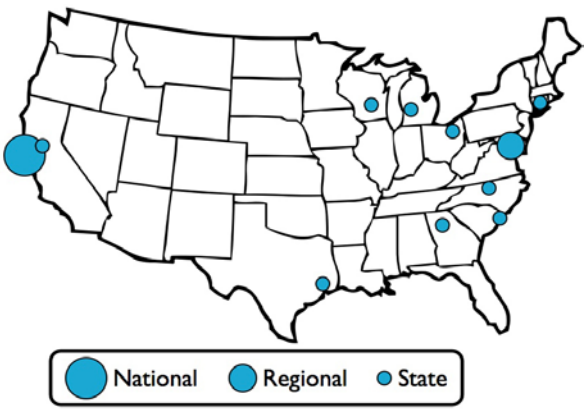

FIGURE 2. Locations of 2010–2011 Conference Presentations

FIGURE 3. Workshop at the National Science Teachers Association Convention, San Francisco, March 2011

and conducted an activity on the fuel cell reaction that they were then given to take back to their classrooms and try out. Figure 3 shows teachers at the National Science Teacher's Association Convention conducting part of Activity 4: Modeling the Fuel Cell Reaction.

Conclusions and Future Directions

Conclusions:

- The complete curriculum module and kit are now commercially available. They have been extensively tested 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.
- A professional development workshop prepared 13 teachers to implement the module in their classrooms.
- Thirteen presentations at national, state, and regional teacher workshops reached over 220 teachers. Reactions to these workshops were positive.
- Evaluations of the curriculum and teacher professional development were highly positive.

Future work will focus on:

- Preparing additional teacher support materials for the project website, including video of how to use and care for the kit equipment.
- Collaborating with the publisher and other partners to disseminate the curriculum, develop teacher leaders, and support new users of the program.

FY 2011 Publications/Presentations

Publication

1. SEPUP. (2011). Investigating Alternative Energy: Hydrogen & Fuel Cells. The Lawrence Hall of Science, University of California, Berkeley. Published by Lab-Aids, Inc. Ronkonkoma, NY.

Presentations

1. Keller, C. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." California Science Education Conference. October 22, 2010. Sacramento, CA.

2. Nagle, B. & Percoski, T. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." Connecticut Science Education Conference. October 30, 2010. Hamden, Connecticut.

3. Nagle, B. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." South Carolina Science Council (SC^2). November 4, 2010. Myrtle Beach, South Carolina.

4. Howarth, J. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." North Carolina Science Teachers Association Professional Development Institute. November 11, 2010. Greensboro, North Carolina.

5. Lenz, L. "Teach Chemistry with Hydrogen Fuel Cells." NSTA Area Conference. November 11, 2010. Baltimore, Maryland.

6. Nagle, B. "Teach Chemistry with Hydrogen and Fuel Cells." Conference for the Advancement of Science Teaching (CAST) 2010. November 12, 2010. Houston, Texas.

7. Lenz, L. "Alternative Energy for Transportation Hydrogen Fuel Cells." Science Education Council of Ohio (SECO). February 12, 2011. Akron, Ohio.

8. Lenz, L. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." Georgia Science Teacher's Association. February 18, 2011. Atlanta, Georgia.

9. Howarth, J. "Alternative Energy for Transportation: Hydrogen and Fuel Cells." Michigan Science Teachers Association. February 26, 2011. Grand Rapids, Michigan.

10. Zoellick, J. SEPUP Pathway Session: "Alternative Energy and Transportation: Hydrogen Fuel Cell and Other Bus Technologies." National Science Teachers Association. March 10, 2011. San Francisco, California.

11. Keller, C. "Teaching About Hydrogen Fuel Cells." National Science Teachers Association. March 12, 2011. San Francisco, California.

12. Willcox, M. "Alternative Energy for Transportation: The Chemistry of Hydrogen Fuel Cells." Wisconsin Society of Science Teachers Conference. March 18, 2011. Wisconsin Dells, Wisconsin.

13. Nagle, B., "HyTEC," FG36-04-GO14277, DOE Hydrogen Program and Vehicle Technologies Program Review, Arlington, VA, May 10, 2011. (http://www.hydrogen.energy.gov/annual_review11_edu.html)

14. Keller, C., and Nagle, B. "Hydrogen Technology and Energy Curriculum (HyTEC)." Workshop presented at the Chabot Space & Science Center's Climate Change Teacher Institute. June 27, 2011.