IX.5 Hydrogen Technology and Energy Curriculum (HyTEC)

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Schatz Energy Research Center
Humboldt State University, Arcata, CA

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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 (3.8.4.1) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- (A) Lack of Awareness
- (C) Institutional Barriers and Access to Audiences
- (D) Regional Differences

Accomplishments

- Prepared complete draft of module, with activities correlated to national and state standards and including topics commonly taught in chemistry and environmental science classrooms.
- Improved the design of the kit materials and produced two sets of student fuel cells and electrolyzers for classroom use.
- Pilot tested revised core activities in Arcata, CA.
- Prepared pre-test and post-test instruments for the curriculum module.
- Prepared for and conducted two-week pilot testing in Emeryville, CA.
- Developed script and filmed two video segments that will integrate into curriculum.

Introduction

This project is producing a curriculum module about hydrogen and fuel cells for high school students. 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 will also investigate students' progress toward the intended learning goals. 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 the past year, work has focused on expanding the curriculum from three core activities to a complete module, developing additional kit components, piloting the expanded module, and developing a video that will be integrated into the module.

Approach

The module has been developed through a close collaboration among the partners. LHS and the Schatz Energy Research Center (SERC) work closely with each other and with teacher associates to develop and revise module activities and kit components. Activities

were piloted by both SERC and LHS staff in California classrooms. Pilot classrooms to date have included several chemistry classes, one advanced placement chemistry class, and one environmental science class. They also included diverse student populations from three significantly different communities in California. The classes were observed by the regular classroom teachers and project staff from LHS or SERC. The observers provided feedback on the activities. In the most recent pilot, students' classroom work and a pre-test/post-test assessment were also used to gather information on student learning.

The module uses an issue-oriented approach to teaching concepts related to chemistry and energy topics. This approach demonstrates to students the relevance of their science education to their lives and the role of scientists and engineers in solving practical problems.

Results

During the 2005–2006 school year, the project built on input from last year's field test in Berkeley High School chemistry and environmental science classrooms to refine the kit materials for the module and to develop and test a draft of the module. This began with revision of the core activities piloted in Berkeley and the production of a classroom set of electrolyzers. The student fuel cells and new electrolyzers were piloted in January by SERC staff in Arcata High School, where students successfully used the hydrogen they generated to lift weights and run a small propeller. The decision to create a separate electrolyzer, rather than to use a reversible fuel cell to generate hydrogen, was based on the need to enhance students' understanding of the difference between the electrolysis reaction and the fuel cell reaction. Figure 1 shows students in Arcata High School in Arcata, California, working with the first set of student electrolyzers.

Based on these trials, a set of improved student electrolyzers and a draft of the complete module were prepared for use in two weeks of pilot testing conducted by the LHS curriculum developers. These tests were conducted in late May through early June in Emery High School, in Emeryville, California. The pilot module included activities on the following topics: energy and transportation, water electrolysis and the production of hydrogen, using hydrogen fuel cells to lift a weight or run a fan, the combustion reaction used in internal combustion engines, the fuel cell half reactions, fuel cell components and their functions, redox reactions, and hydrogen fuel cell vehicles and a hydrogen economy.

Figure 2 shows students in Emery High School using their hydrogen to operate a fuel cell and run a propeller. Students in this inner city classroom were generally unaware of energy alternatives for transportation before the module began. The culmination of the module was a visit to the school by an Alameda-Contra Costa Transit Authority (AC Transit) hydrogen fuel cell bus. Students rode on the bus and had their questions about its performance and advantages answered by the driver and AC transit's Director of Marketing and Alternative Fuels Policy. Figure 3 shows Emery High School chemistry students and their teacher with an AC Transit hydrogen fuel cell bus.

The pilot revealed many ways to improve the flow of the materials for students, to clarify the written procedures and questions, and to connect the activities to students' lives and interests. Pilot testing in three different schools provided information about how to adapt the module for students with different backgrounds. In all settings, the unit provided an excellent opportunity to apply and review chemical concepts that had been introduced earlier in the course,

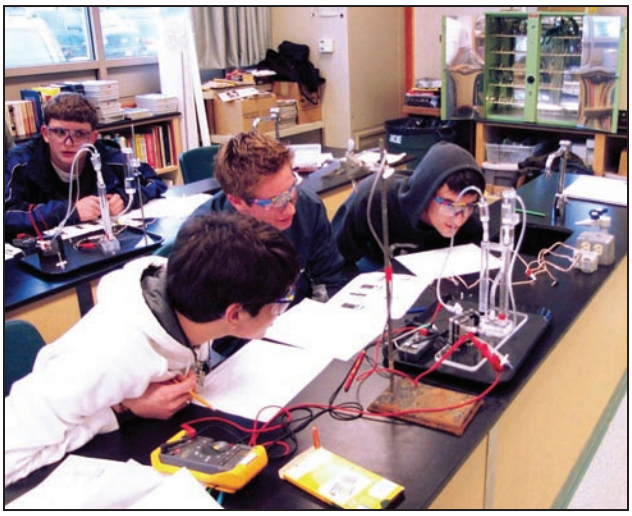

FIGURE 1. Arcata High School Chemistry Students Using Their Electrolyzer to Produce Hydrogen

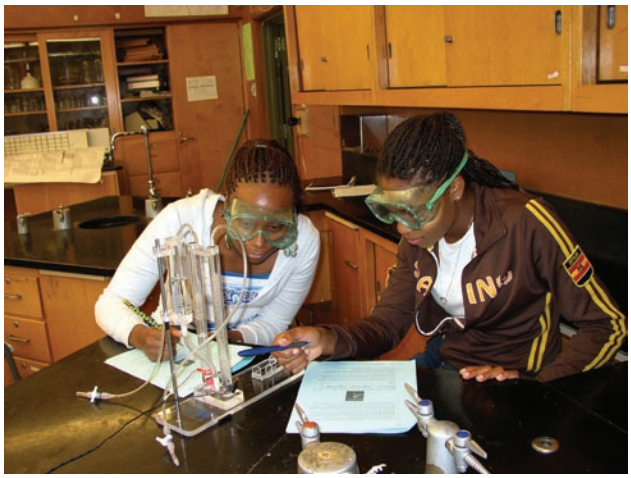

FIGURE 2. Emery High School Chemistry Students Using a Hydrogen Fuel Cell to Run a Propeller

FIGURE 3. Emery High School Chemistry Students and their Teacher with AC Transit's Hydrogen Fuel Cell Bus and Director of Marketing and Alternative Fuels Policy

such as stoichiometry, reactions, and gas laws. In the longer pilot in Emeryville, the unit was also related to electrochemistry, redox reactions and equations, and half-reactions.

The classroom teachers in Arcata and Emery High Schools are positive about the module and its fit in their classrooms and hope to continue using the unit. Arcata High School is seeking funding for their own set of equipment and both schools would like to continue working with the HyTEC project. Results from the students' pre-tests and post-tests are still being analyzed.

The project also developed a script and completed filming of a two-part video that will accompany the curriculum. The video includes an introduction to the first activity of the module and a "video field trip" to be shown after students have used the fuel cells in the classroom activities. This will provide the real-world connection between what students have observed in the classroom and research and development of hydrogen fuel cell technology.

A Stack-in-a-Box® portable fuel cell system has also been developed for use by LHS in San Francisco Bay Area classrooms. It can be used to run small household electrical appliances, like a light bulb or blender. Students can operate the system, and using the ideal gas law and the heat of reaction for hydrogen they can calculate the efficiency of a real world fuel cell system.

Conclusions and Future Directions

The instructional activities and kit materials developed for the HyTEC module allow students to produce hydrogen and investigate fuel cells and the fuel cell half reactions in the context of chemistry or environmental science classrooms. They introduce students to efforts to develop hydrogen and fuel cells as a viable option for transportation and to some of the challenges that must be overcome to develop a hydrogen economy. Teachers and students are positive about the curriculum and excited by the opportunity to work with the fuel cells and learn about current research and development.

In the future, the module will be revised based on the recent classroom trials. The video will also be completed and integrated into the curriculum module. Current funding will support presentations of the module at science teaching conferences and may allow for one more classroom trial. However, without additional funding, it will not be possible to conduct the national trials envisioned for the original fully-funded project.

FY 2006 Publications/Presentations

1. Nagle, Barbara, "Hydrogen Technology and Energy Curriculum (HyTEC)," presentation to the 2006 DOE Hydrogen Program Review," May 17, 2006.