X.5 Hydrogen Technology and Energy Curriculum (HyTEC)

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

Start Date: September 1, 2004
Projected End Date: August 31, 2009

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

- Lack of Awareness
- Institutional Barriers and Access to Audiences
- Regional Differences

Approach

- Draft module outline prepared by developers
- Teachers, curriculum developers, and scientists on the team review and revise
- Draft core activities & assessments, develop kit materials, including student fuel cell
- Review of activities by teacher advisors
- Pilot by developers working in San Francisco Bay Area classrooms

- Collect teacher, student, and expert feedback
- Revise based on feedback
- Team science centers, scientists, and schools to create a collaborative model for hydrogen and fuel cell education
- Include Stack-in-a-Box® activities facilitated by scientists, science center personnel, or participating teachers:
  - Illustrate the use of fuel cell stacks for real energy needs
  - Investigate additional scientific concepts

Accomplishments

- Completed outline (15 activities) correlated to National Science Education Standards reviewed by team
- Developed prototype kit materials
- Developed three activities for classroom use
- Pilot tested three core activities in Berkeley Unified School District

Future Directions

- Complete student fuel cell and kit prototypes
- Completion of trial unit, with complete activities
- Classroom trial of complete unit with kit and fuel cell stack (Stack-in-a-Box®)
- Revision based on feedback
- Prepare an online field trip to a hydrogen fueling station and fuel cell bus facility
- Pending future funding, prepare two more modules and nationally field test the modules
- Pending future funding, revise and publish the modules

Introduction

This project is intended to produce curriculum materials about hydrogen and fuel cells for high school students. In order for such materials to be widely usable throughout the United States, it must address topics teachers usually teach and correlate to the National Science Education Standards and/or state and local standards. This project brings together 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 to develop commercial educational modules that will fit into high school courses such as physical science, chemistry, environmental science, and physics.

Approach

To date, a draft outline of an instructional module and a classroom set of prototype kit materials have been developed. The instructional materials and puzzle pieces were developed by LHS. Prototype kit materials were developed by the Schatz Energy Research Center (SERC) at Humboldt State University, and include ten student fuel cells, one fuel cell that can be disassembled to show the fuel cell components, and eight gas storage devices. The module activities were drafted and field tested by two LHS staff members in five Berkeley High School classrooms. These included three chemistry classes, one Advanced Placement Chemistry class, and one environmental science class. The classes were observed by a curriculum developer and the regular classroom teachers, who provided feedback on the activities.

During the classroom trials, students investigated the ability of student fuel cells to power a motor and lift a mass, used models to investigate the fuel cell reaction, and used chemical cells and fuel cells to explore the half reactions involved in electrolysis and fuel cell operation. For these activities, they used eight student gas storage devices and prototype student fuel cells developed for this project by SERC.

Results

The module outline currently includes 15 activities and would take approximately one month to teach. This is a relatively long period of time in the classroom, so it is important that the unit will include a number of topics that are normally included in the curriculum. The outline includes activities on: Energy Sources and Tradeoffs, Energy and Transportation, Using Hydrogen Fuel Cells to Move Things, Half Reactions and Electrochemistry, Oxidation/Reduction, Electrochemistry, and Batteries, Electrochemical Cells vs. Fuel Cells, Fuel Cell Design and Function, Comparing Emerging Technologies, Producing Hydrogen, Hydrogen Fuel Cell Vehicles and a Hydrogen Economy, and Making Decisions about Hydrogen and Fuel Cells.

The three activities field tested in June generally went well in the classroom. The eight student fuel cells worked well: students working in groups of four were able to run three trials with the fuel cells, collect data, and calculate the efficiency of the cells in lifting a 1-kg mass. Figure 1 shows students in a chemistry classroom in Berkeley High School working with the apparatus. Students were also successful in using atomic puzzle pieces to model the fuel cell reactions and indicated that the models helped them to understand the reactions. Figures 2 and 3 show the puzzle pieces used to model fuel cell reactants and products. They are arranged on a template that represents the sides of the fuel cell. The teachers were generally positive about the activities and their fit into their courses. One finding was that the unit provided an excellent opportunity to apply and review chemical concepts that had been introduced earlier in the course, such as stoichiometry, reactions, electrochemistry, half-reactions, and gas laws.

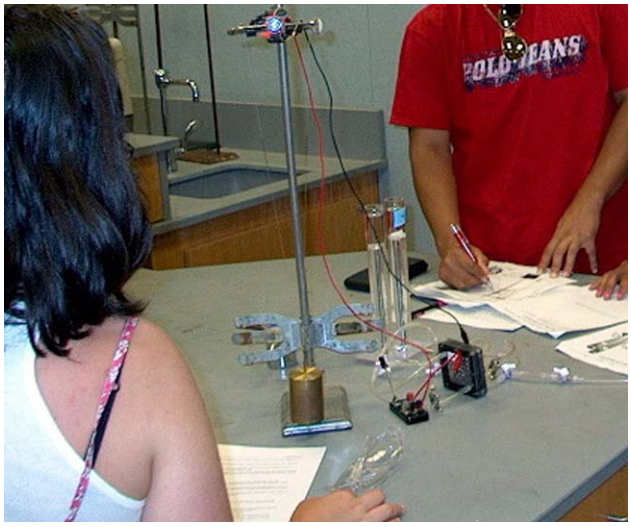

Figure 1. Student Fuel Cells in a Berkeley High School Classroom

Conclusions

The instructional activities and prototype kit materials allow students to investigate fuel cells and the fuel cell half reactions. They fit into courses in chemistry and environmental science and support instruction in topics that are part of the curriculum in these courses.

FY 2005 Publications/Presentations

1. Nagle, Barbara, "Hydrogen Technology and Energy Curriculum (HyTEC)," presentation to the 2005 DOE Hydrogen Program Review," May 26, 2005.

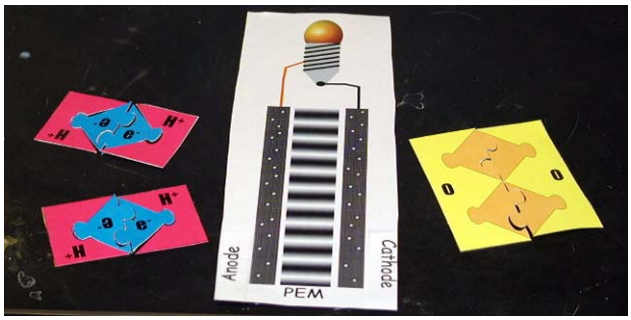

Figure 2. Puzzle Pieces Used to Model Fuel Cell Reactants

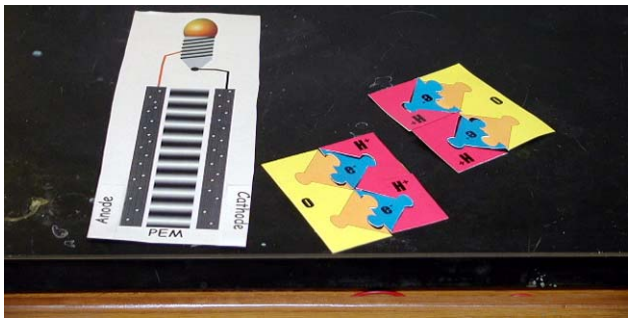

Figure 3. Puzzle Pieces Modeling Fuel Cell Products