Hydrogen Technology and Energy Curriculum (HyTEC)

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Project ID #ED1

HyTEC Collaborators

Lawrence Hall of Science
University of California, Berkeley

SCHATZ ENERGY RESEARCH CENTER

AC TRANSIT

Overview

- **Timeline**
  - September 1, 2004
  - August 31, 2006
  - 70% complete
  - Extension taken for Project Period I
- **Budget**

Total five year: $3,015,955
DOE share: $2,399,150
Contractor share $616,805
Funding FY04: 410,395
DOE share: $324,983
Contractor share: $ 85,412
Funding FY05: none
Funding FY 06: none

- **Barriers addressed**
  - Lack of Awareness
  - Institutional Barriers and Access to Audiences
- **Partners**
  - Core:
    - SERC, Humboldt State
    - AC Transit
  - Additional:
    - Chabot Space & Science Center
    - NHA
    - Lab-Aids, Inc.
    - Filmsight Productions

Goal

- Educate high school students and their teachers about the
  - Scientific and technological basis for hydrogen and fuel cells
  - Research and development currently underway to implement safe and cost-effective hydrogen and fuel cell transportation demonstration programs
  - Current challenges to and potential promise of a hydrogen economy in the broader context of energy use and resources.

Project Objectives

- Develop, field test in national centers, 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.

Project Objectives: The Curriculum Envisioned

- Part of the SEPUP module series developed at UC Berkeley's Lawrence Hall of Science
  - Twelve modules currently available
  - Recognized for balanced treatment of issues
  - Marketed nationally by Lab-Aids, Inc.
  - Disseminated through numerous national, state, and regional workshops/presentations
  - Used with pre-service teachers in many schools of education
- Integrated into SEPUP's 2-year high school science program (funded by NSF)

Project Objectives:
A SEPUP Instructional Module

Hazardous Materials Investigations Module

- Complete materials kit
  - Equipment
  - Consumables (chemicals)
  - Transparencies
- Teacher's Guide
  - Student Masters
  - Transparency Masters
  - CD of test and masters
- Web site for support, links to other resources, extensions

Objectives: Year One

The plan has been modified to fit the greatly reduced funding level and uncertainty of future funding

- Prepare a draft of one module that includes the most important ideas related to hydrogen and fuel cells
  - Related to National Science Education Standards and other standards
  - Able to fit into a typical high school chemistry and/or environmental science course
- Pilot the module in local classrooms
- Revise to prepare a version for piloting by expert teachers

Approach

- (Complete) Draft module outline prepared by developers
- (Complete) Teachers, curriculum developers, and scientists on the team review and revise
- (80% complete) Draft core activities & assessments and develop prototype kit materials, including student fuel cells and one Stack-in-a-Box® fuel cell stack for demos
- (40% complete) Develop a video introduction and field trip--a Year Two objective
- (30% complete) Pilot by developers working in San Francisco Bay Area classrooms
- (10% complete) Collect teacher, student, and expert feedback
- Revise based on feedback

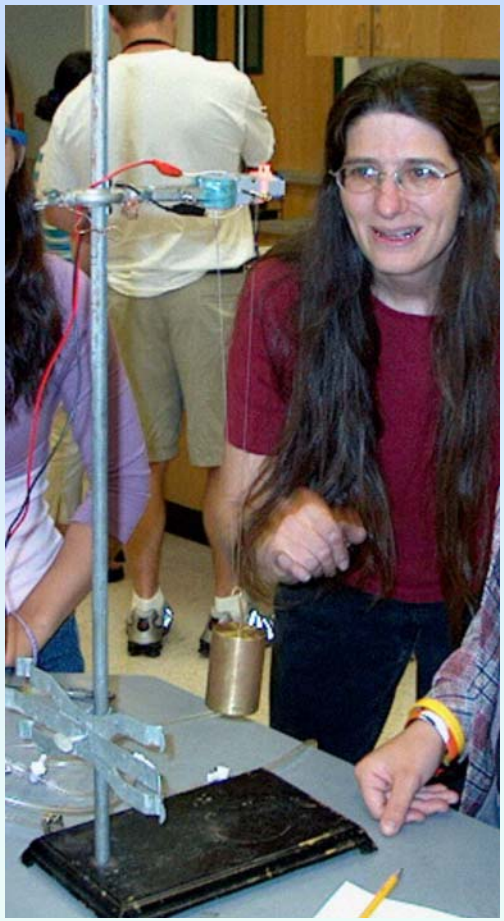
Approach, continued

- Team science centers, scientists, and schools at all stages of the project, to create a collaborative model for hydrogen and fuel cell education

Progress (2004–2005)

- Development and review of module outline
- Correlation of planned module to National Science Education Standards
- Development of prototype kit materials (student fuel cell)
- Development of core set of three hands-on activities
- Pilot tested three core hands-on activities in Berkeley Unified School District in June, 2005
- Focus on solving technical problems

Pilot testing: Berkeley, CA



Kate Haber (shown) and Lee Amosslee, two former Berkeley High School teachers, worked full time with LHS last year and conducted the classroom field trials in June.

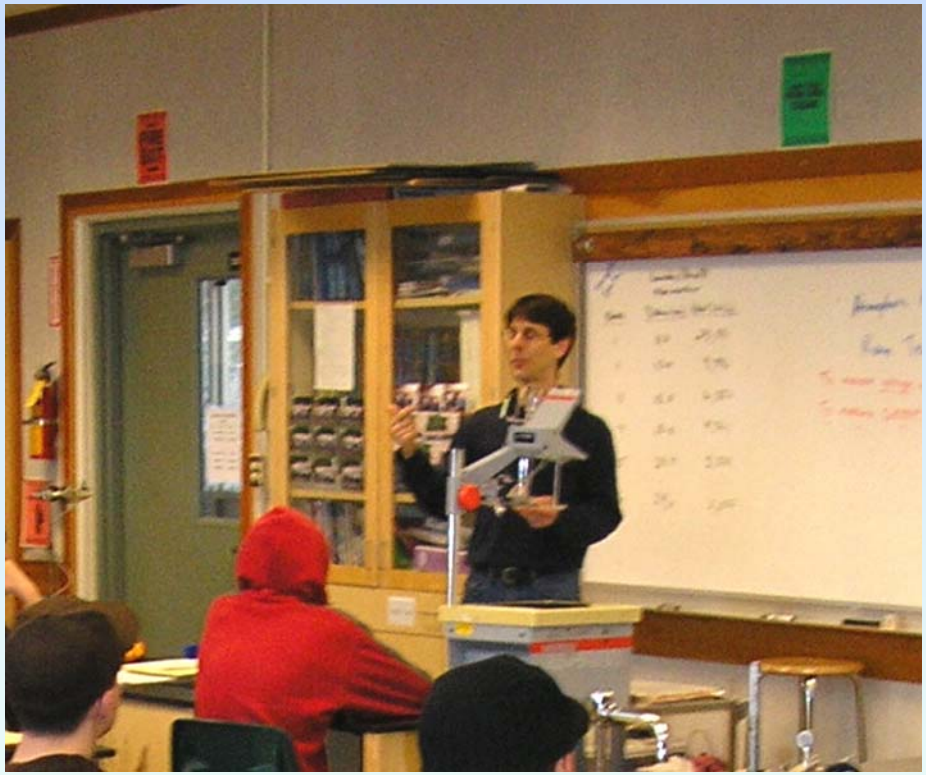
Trials were held in three chemistry classes and two environmental science classes.

This photograph shows the 1 kg weight being lifted by the student fuel cells.

Progress (2005–2006)

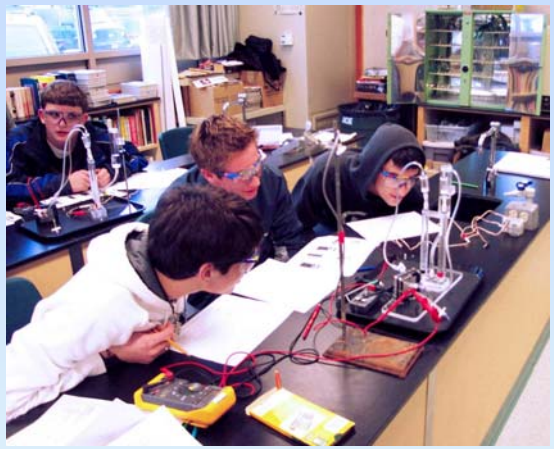
- Refined the design of the kit materials and produced a set of eight student electrolyzers
- Pilot tested revised versions of the activities and new equipment in Arcata, CA in January, 2006
- Prepared drafts of ten activities for pilot testing.
- Prepared a pre-/post assessment instrument.
- Developed script for two video segments that will integrate into the curriculum (for filming in May)
- Pilot testing of a two week sequence planned for May/June, 2006 in the San Francisco Bay Area

Pilot testing: Arcata, CA



Jim Zoellick, SERC engineer, pilot testing in Arcata High School, CA in January, 2006

Pilot testing: Arcata, CA



- Students watch their HyTEC electrolyzer decompose water to produce hydrogen and oxygen gas.
- Students operate a HyTEC fuel cell to power a motor and lift a weight.
- Electrolysis is separated from the fuel cell operation, to enhance students' understanding.

Curriculum incorporates chemistry topics

- Electrochemistry
- Oxidation-reduction
- Half reactions
- Balancing equations
- Heats of reaction
- Bond energies
- Energy transformations

Value of the issue-oriented approach

- Demonstrates to students the relevance of their science education
  - Chemistry they are learning in class relates to interesting and exciting real world problems
  - The skills they are learning can enable them to work on solving some of the worlds energy and pollution problems
- Issue-oriented science motivates students to learn science, continue science education, consider careers in science and technology, and have positive attitudes toward science

Student and teacher response

- Students
  - "It was really fun."
  - "The fuel cells were really cool."
  - "This is a valuable part of a curriculum, and should be taught in every school in the nation!"
- Teachers
  - Appropriate for either chemistry or environmental science
  - Teacher reviewer requested an activity to use in her environmental science classroom in the Seattle area
  - Arcata High School has obtained funding for a classroom set of the equipment so they can continue to teach the activities

Future work

With current funding:

- Complete pilot testing of all module activities this spring
- Complete the video: introductory and field trip segments tied to the curriculum
- Review of the module by additional teachers, educators, and scientists
- Revise activities based on input from pilot testing and review

Stack-in-a-Box® Investigations

- A Stack-in-a-Box® portable fuel cell system is shown in these photos. 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.
- One has been developed for use in the Lawrence Hall of Science and in SF Bay Area classrooms. It will be used in the spring classroom pilots.

Future work (continued)

Regardless of additional DOE funding:

- Conduct workshops for teachers
  - California Science Teachers Association (10/06, accepted)
  - National Science Teachers Association (3/07, proposed)
- Conduct 4-day student program
  - In association with NHA Annual Conference (3/07, proposed)
  - In three San Antonio schools

Future work

With continuing funding:

- Expansion of program to three modules, for physical science and chemistry classes
- National field testing with diverse student populations, in a variety of sites
- Stack-in-a-Box® unit for each national field test site
- Professional development program, building on LHS, SERC, and CS&SC experience
- Commercial publication of module with kit
- National dissemination through LHS and established publisher network, catalog, and sales team

Summary

- Objective: To develop and test a high school module on hydrogen and fuel cells.
- Approach: Team of scientists, curriculum developers, and teachers develop materials and test in schools. Materials integrate into courses and emphasize relationship of hydrogen and fuel cells to content teachers need to include.
- Progress: Core activities developed and piloted twice. Complete module draft developed. Video introduction and field trip in progress.
- Proposed future work: Complete this module and two additional modules, disseminate nationally, and use the curriculum and video as the basis for teacher professional development.

Responses to Previous Year Reviewers' Comments

- Focus more on teacher professional development.
  - Presentations planned for 2006 and 2007.
  - Our approach is teacher professional development through curriculum implementation and partnering with science center and scientists.
  - Pilot and field testing experiences provide evidence for designing the professional development and cadre of teachers to conduct it.
- Connect to DOE labs and communities.
  - Making connections to Lawrence Berkeley Laboratory and Sandia National Laboratories.

Critical Issues and Strategies to Address Them

- Adding hydrogen and fuel cells into an overloaded high school curriculum
  - Integrating into existing high school standards and approaches
  - Flexible models, from core of 3 activities to a full 10-activity module
- Reducing the cost of the kit materials for schools
  - Working with experienced engineers and kit producers

Critical Problem

- Project continuity
  - Maintaining staffing and momentum with uncertain funding
  - Building relationships with teachers and schools and disseminating a project with an uncertain future