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

LAB-aiDS INCORPORATED

Overview

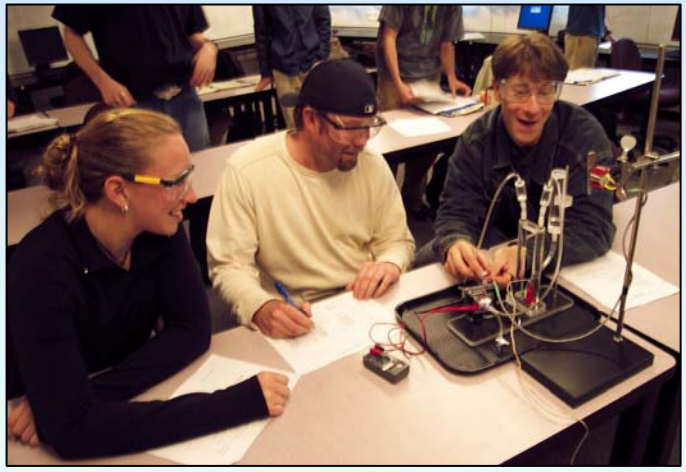
- **Timeline**
  - September 1, 2004 start
  - Phase One 100% complete
  - Currently under 2nd no-cost 18-month extension
- **Budget**

Total funding: $3,015,955
DOE share: $2,399,150
Contractor share $616,805
Funding FY04: $410,395
Funding FY05: none
Funding FY06: none
Funding FY07: $300,000
DOE share: $150,000 (pending)
Contractor share $150,000

- **Barriers addressed**
  - Lack of Awareness
  - Institutional Barriers and Access to Audiences
- **Partners**
  - LHS, UC Berkeley
  - SERC, Humboldt State
  - AC Transit
  - Filmsight Productions
  - Lab-Aids, Inc.

Goals

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



Equipment Testing at Humboldt State

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.

Approach: The Curriculum Envisioned

- Part of the SEPUP module series developed at UC Berkeley's Lawrence Hall of Science
  - Issue-oriented science curriculum
  - 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)

Approach:
A SEPUP Instructional Module

"Investigating Energy from the Sun" 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: Project Period One

The plan was modified to fit a 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 physical science course
- Pilot the module in classrooms
- Revise to prepare a version for piloting by expert teachers

Approach & Progress

- (Complete) Draft module outline (10 activities), correlate to National Science Education Standards
- (Complete) Teachers, curriculum developers, and scientists on the team review and revise
- (Complete) Draft core activities & assessments, develop kit materials, including student fuel cell & electrolyzer
- (Complete) Teacher advisors review activities
- (Complete) Developers pilot core activities in Northern California classrooms
- (90% Complete) Collect teacher, student, and expert feedback
- (90% Complete) Revise based on feedback
- Team science centers, scientists, and schools to create a collaborative model for hydrogen and fuel cell education

Approach

The curriculum incorporates numerous chemistry topics, including:

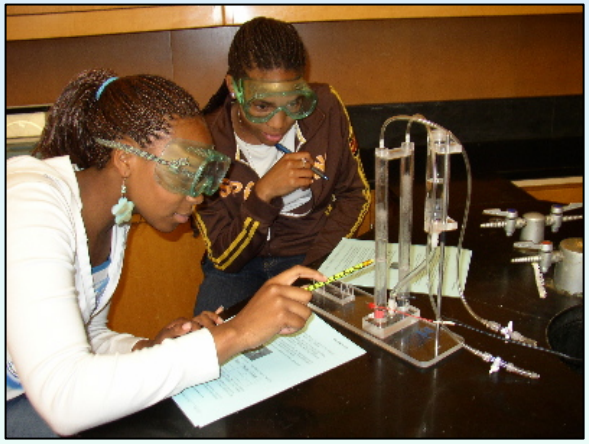
- Electrochemistry
- Oxidation-reduction
- Half reactions
- Balancing equations
- Heats of reaction
- Bond energies
- Energy transformations

Introductory Lecture at Arcata High

Accomplishments

Five curriculum activities have been fully developed, tested, and revised, including:

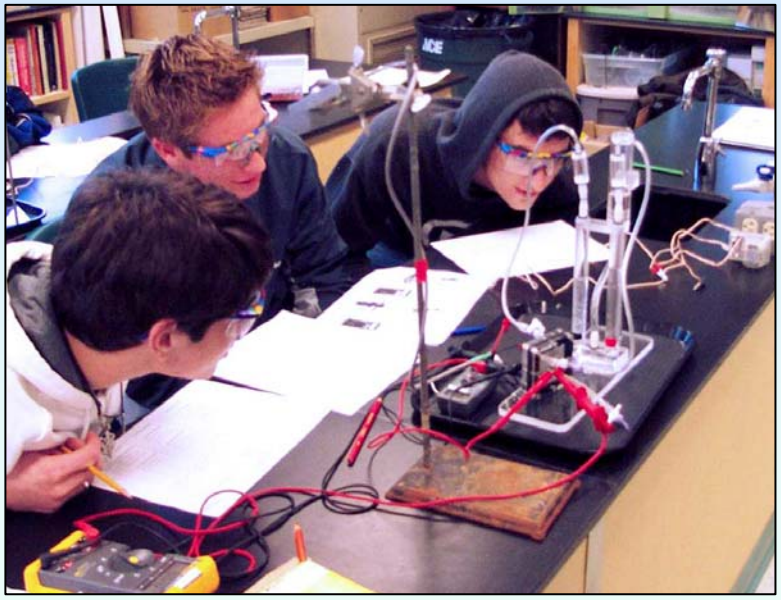
1. Energy for Transportation - students examine trade-offs of various fuel/vehicle combinations
2. Fuels - students examine and compare various fuels (octane, methane, hydrogen, ethanol), they determine the heat of combustion, energy density, and CO_2 emissions for these fuels
3. Obtaining Hydrogen through Electrolysis - hands-on lab, students generate hydrogen and examine the required energy input, stoichiometry, and electrochemistry involved in the process



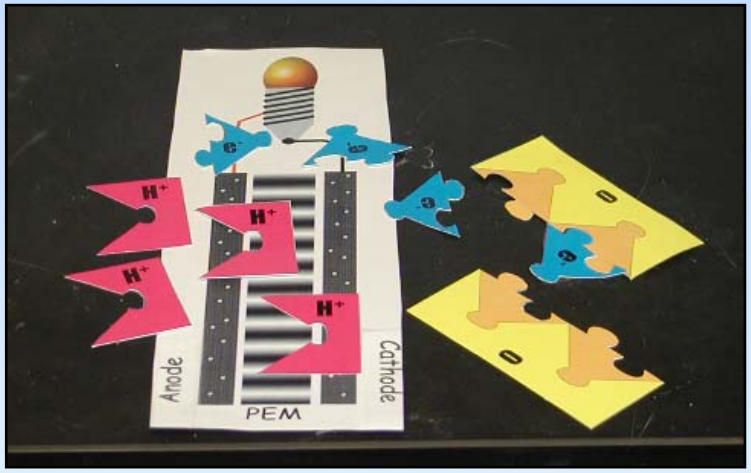
Classroom Trials at Emery High

Accomplishments

4. Putting a Hydrogen Fuel Cell to Work - hands-on lab, students generate H2 and O2 via electrolysis, use a single cell fuel cell to perform work, measure fuel cell efficiency



Classroom Trials at Arcata High

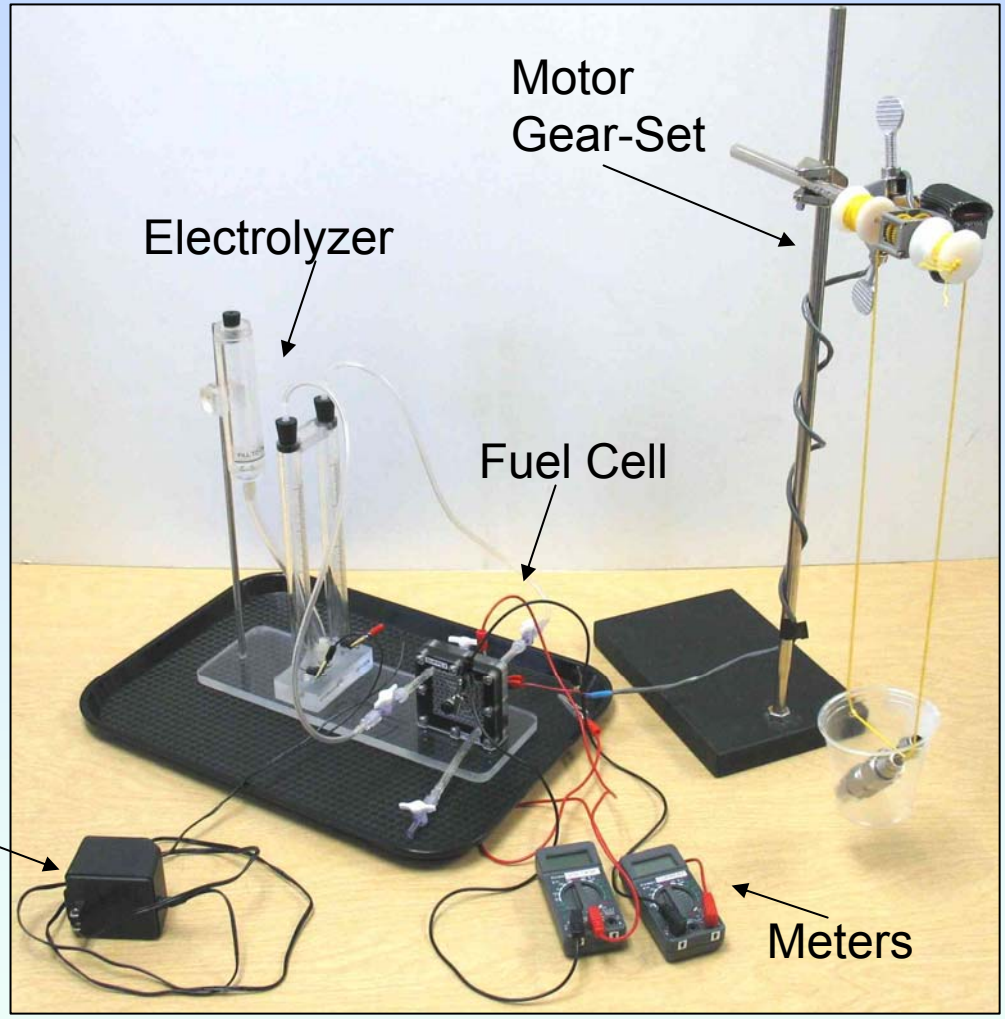


Fuel Cell Redox Model

5. Modeling a Fuel Cell Redox Reaction - students use model pieces to explore the fuel cell redox reaction

Accomplishments

A hands-on fuel cell and electrolyzer laboratory kit has been developed, tested, & revised



Accomplishments

Classroom curriculum trials have been conducted at:

- Berkeley High School

3 chemistry classes
2 environmental science classes
140 students

- Emeryville High School

2 chemistry classes
50 students

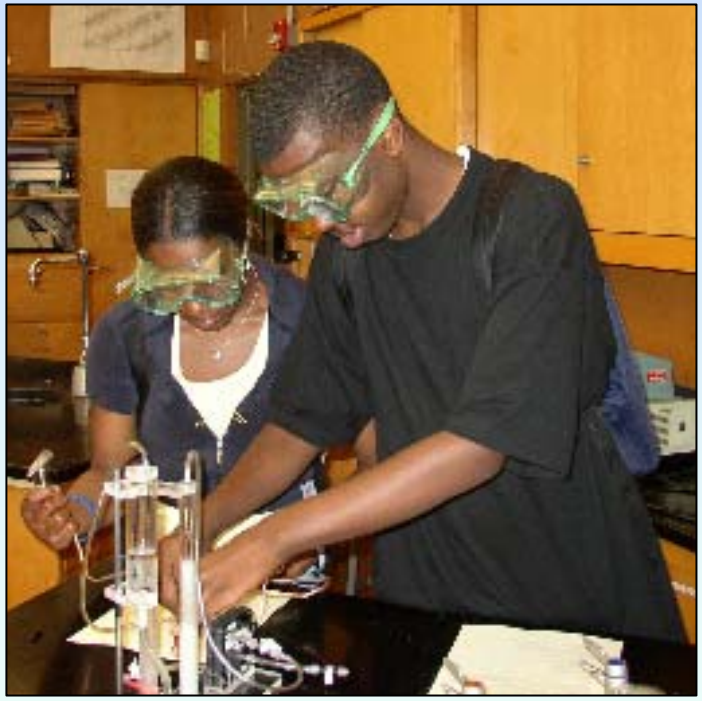
- Arcata High School

4 chemistry classes
100 students

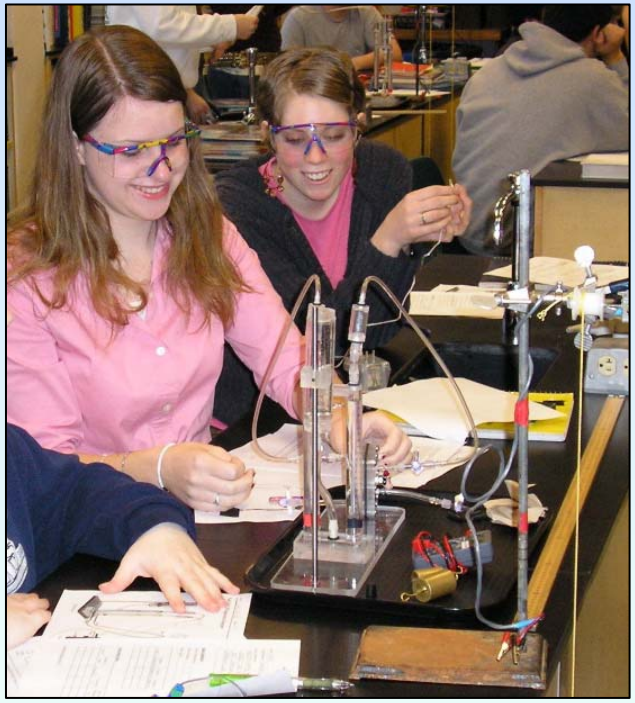
Emery High School

Accomplishments

We have tested the curriculum with a diverse group of students (e.g., urban, rural, multiple socio-economic classes).



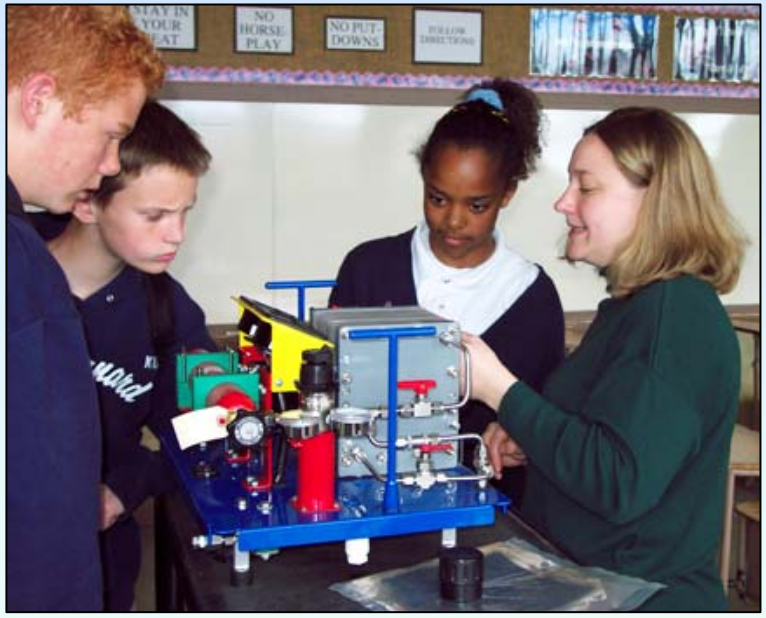
Emery High School



Arcata High School

Accomplishments

A Stack-in-a-Box® has been produced for use by the Lawrence Hall of Science and in SF Bay Area classrooms.

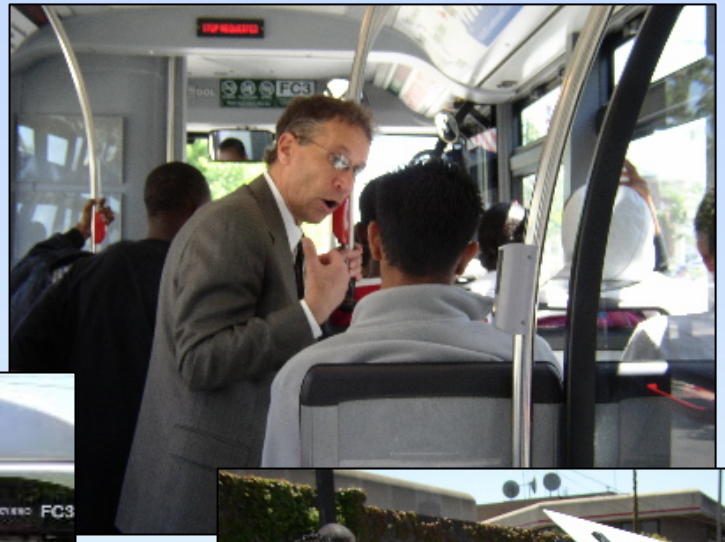


Stack-in-a-Box® Demo

Stack-in-a-Box®

Accomplishments

Field Trip - Emeryville High students ride an AC Transit fuel cell bus.



Accomplishments

Two video segments have been produced using teenage actors.

1. A “teaser” introduction.

2. A virtual field trip.

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 responses

- 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 Seattle area
  - Arcata High School purchased 15 fuel cell / electrolyzer kits and two chemistry teachers have integrated the fuel cell and electrolyzer labs into their curriculum
  - Emery High School teacher has attended multiple conference presentations and wants to continue to be involved

Presentations

- "Teaching Chemistry with Hydrogen Fuel Cells," California Science Teacher's Association Conference, October 21, 2006 San Francisco, CA
  reached about 50 teachers

- "Teaching Chemistry with Hydrogen Fuel Cells," National Science Teacher's Association Conference, March 31, 2007 St, Louis, MO
  reached about 40 teachers

Future work

- More classroom trials in May ‘07
- Next round of curriculum revisions
- Develop flexible model allowing use of complete sequence or parts of sequence
- Finalize and prepare curriculum activities for publication
- Teacher training workshops (Summer ‘07)
- Development of interactive, web-based tool (fuel cell simulation, video clips, additional resources)
- Development of fuel cell kit into production level product that can be widely disseminated
- Continue to present to teachers (NSTA ‘08)
- Field test materials in limited number of sites outside Northern California

Summary

- Goal - To develop an NSES correlated hydrogen and fuel cell curriculum for high schools and a model to disseminate it nationwide
- Project scope was reduced due to funding shortfalls
- Substantial commitment of outside funds has allowed the project to continue
- A core curriculum module with laboratory activities and equipment has been successfully developed and tested
- With remaining funding we plan to finalize the curriculum module, prepare it for publication, develop a production level laboratory kit, conduct teacher trainings, and begin to market the curriculum nationally