

HYDROGEN EDUCATION OUTREACH

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Abstract

The objective of the Hydrogen Education Outreach effort is to educate students and teachers about the properties and benefits of hydrogen, its technology applications and potential as a fuel and energy carrier. To date, the primary target market for this activity has been secondary school students, although the ultimate range of audiences includes kindergarten thru college. Informal education for non-technical students of all ages is likewise a part of the Education Outreach mandate. There have been two main types of Education Outreach activities: instructional materials and live science shows.

A formal curriculum entitled *The Clean Corridor Curriculum*, has been prepared for use in high school chemistry classes. Now in the field test phase, the curriculum will be revised during a summer workshop preparatory to any additional field-testing and distribution through appropriate marketing channels. From that first curriculum, a middle school version will also be produced. This summer's workshop is expected to develop a first cut, though not a complete version of the middle school product.

The live science shows have been built around *The Dr. Bob Show*, now the centerpiece of the *Secondary School Invitational* and the focus of live on-school site science programs. These shows were filmed this year. They are expected to yield the beginning of a suite of film products that will support the instructional materials and complement other EERE outreach activities while supplementing its video library. Further work with film professionals will occur in FY2000 and beyond.

The fun in Hydrogen Education Outreach has only just begun.

Objective

The Hydrogen Program has for some time included education outreach in its portfolio. The objective of the Hydrogen Education Outreach effort is to educate students and teachers about the properties and benefits of hydrogen, its technology applications and potential as a fuel and energy carrier. The target market for this activity is secondary school students and teachers. However, the broader audience for this activity ranges from kindergarten through college and beyond to include informal education for non-technical audiences of all ages.

Technical Goals

The technical goals of Hydrogen Education Outreach are twofold:

- #1 to develop and disseminate instructional materials and educational tools, including audio-visual materials such as videos and video-clips that are consistent with the contemporary inquiry-based pedagogy and practice of science education; amenable to distribution through proven and promising marketing channels.
- #2 to produce live science education shows to inform and educate target audiences.

All discussion of past results, current activities and future plans will reflect these two technical goals.

Past Results

Although the Hydrogen Program has placed great emphasis on development and dissemination of instructional materials, the work actually began with a live science show -- *The Dr. Bob Show*. It is therefore appropriate to begin the story with the second technical goal, namely, *to produce live science education shows to inform and educate target audiences*. The order of consideration of the technical goals will shift from section to section within this paper on Hydrogen Education Outreach depending on the logic and significance of each goal to that period's activities.

Live Science Education Shows

Inspired by the experience of lifetime professional educator Dr. Robert Reeves, Professor Emeritus at Rensselaer Polytechnic Institute (RPI), the DOE Hydrogen Program created the *Dr. Bob Show*. The show, designed to teach students about the promise of a hydrogen future, originated as part of the National Hydrogen Association Conference, an established outreach opportunity. The *Dr. Bob Show* quickly became the centerpiece of an annual seminar called the *Secondary School Invitational*. This

year, the 10th year anniversary for the National Hydrogen Association Annual Conference, marked the third annual *Secondary School Invitational*.

The Secondary School Invitational and The Dr. Bob Show

Built around the *Dr. Bob Show*, the *Secondary School Invitational* incorporates the annual conference theme to educate and entertain secondary school audiences about hydrogen and the global environmental condition. The morning features the *Dr. Bob Show*; the afternoon offers hands-on opportunities to experience live science, some of it *Dr. Bob* style. Special events, such as last year's live debate on renewable energy that celebrated the selection of renewable energy issues as the 1997-98 academic year national forensic topic, are regularly included. After thorough exposure to the delight of science experimentation, the afternoon typically concludes with a career panel, Career Opportunities of a Lifetime: COOL. This forum introduces students to real live science and engineering professionals. The panelists, at various stages of their careers, explore the rewards and requirements of possible technical career paths. Awards and closing follow.

Production of this live show has expanded to non-NHA school locations. On-site productions have added a different dimension to the science show experience. This year's *Dr. Bob Show* at the *Secondary School Invitational* and the school-site production were filmed with the expectation of producing a *Dr. Bob Show* video. The availability of a video *Dr. Bob Show* would allow us to reach measurably larger student audiences. The video would be used to supplement the high school and middle school curricula. It could be used for informal education on a stand-alone basis.

Instructional Materials

While the *Dr. Bob Show* provided a platform for the education outreach activities, the development and packaging of instructional materials in a coherent curriculum has been an important objective for the Hydrogen Program. As a result of a summer 1998 workshop this objective has been achieved with broad technical support across the Program and in-depth review by key members of the Hydrogen Program team. The result is called *The Clean Corridor Curriculum (CCC)*, a high school curriculum that educates students about the potential and benefits of hydrogen as a fuel and energy carrier.

The Clean Corridor Curriculum (CCC)

The CCC is intended as a flexible complement and enrichment to both traditional and innovative approaches to chemistry education. The curriculum emphasizes chemistry fundamentals, meeting 80-85% of the national standards for chemistry. Relevant learning in physics and biology is also included and mathematics cross-cuts the curriculum. Importantly, the CCC highlights current and advanced hydrogen related technologies. The target audience is first year chemistry students. While the curriculum is aimed at the average chemistry student, extension activities that target

other student populations (technical education, honors and advanced placement) are also included.

Both the curriculum structure and content reflect the contemporary pedagogy and practice of science education. All learning is linked to national science standards, and for the state of Maryland, state standards. The Hydrogen Program's vision underlies *The Clean Corridor Curriculum*, imagining a world in the not too distant future, where:

. . .health, environment energy security and the economy will contribute to the creation of Clean Corridors in America. The Clean Corridors will use cleaner, more efficient and more environmentally friendly technologies and fuels to serve a variety of needs in the building, utility, industrial and transportation sectors.

The curriculum is organized in five modules and a final project:

Fundamentals (contains three units called Learning about Hydrogen; Naming Hydrogen Containing Compounds; and Equations)
Production
Storage
Distribution and Safety
Utilization
final project: Hydrogen Filling Station Project

The Fundamentals units, uses hydrogen as a cross-cutting theme to teach a basic course in chemistry. The other four modules use the transportation sector as a vehicle for learning. Concern for the global environment unifies the lesson content.

Lessons are structured in a 5E format with engagement, exploration, explanation extension and evaluation components. Based on constructivist education philosophies, the 5E format is sometimes referred to as the learning cycle.

Several CCC teaching approaches are possible:

The Curriculum may be taught in its entirety using all five modules and the final project
Individual modules may be used as needed.
Lessons from one or more modules and/or the final project may be used.
The final project may be taught as a stand-alone unit.

Current Accomplishments

Instructional Materials

During the 1999 fiscal year, technical review of the *Clean Corridor Curriculum* was completed. The curriculum is now in the field test phase. A field-test introduces new and revised curricula in classrooms on a targeted basis to

assess its merit and utility. The results are evaluated to provide guidance for revisions and enhancement of the educational material.

Field Test and Evaluation

Field-testing and evaluation are best practices in the education industry. They are a crucial step in the process of successfully disseminating the CCC to the widely decentralized high school science education market. With changing science standards and increasing performance pressures, and science approaches ranging from traditional to innovative, educators face enormous challenges in serving highly diverse student populations. School districts across the country make curriculum choices on a fairly autonomous basis, acting independently of each other and, not infrequently, their state departments of education. From a marketing perspective, the field-testing and evaluation process positions the CCC in the minds of the decision makers -- teachers and administrators who select curricula and support classroom materials.

Through an existing network of educators and participation in the National Science Teachers= Association (NSTA) Annual Conference in Boston, teachers have been solicited to participate in the field test and evaluation of the CCC. The following considerations affected the teacher recruitment process: geographic representation, diversity of school districts, and commitment to science education reform consistent with national standards. As stipend funding was unavailable for this effort, teachers are participating in the field test based on interest and in exchange for a free copy of the *Clean Corridor Curriculum*. Teachers who received the curriculum are from: Florida, New Mexico, New England, New York/New Jersey, Maryland, the south and the west.

Teachers were asked to devote 10 hours of classroom time to this effort. However, since the field test began late in the school year following the in-house technical review, and since teachers will not be paid for this effort, it is not expected that all interested teachers will actually be able to devote the optimal time amount to the field test. Sadly, the Littleton tragedy has reportedly also had an impact, siphoning off discretionary time that might have been used for the field test. However, it is expected that a sufficient number of field test teachers will provide the guidance necessary to effectively modify the CCC in the near term.

Curricula Workshops

Accordingly, a two week workshop is planned for this summer to revise and enhance the high school curriculum. Revisions will draw heavily from the results of the field-test and evaluation. One expected modification will be the creation/enhancement of activities that target different segments of the high school chemistry population (i.e., technical education, general, honors and Advanced Placement.) It is anticipated that the same individuals who participated in last year's workshop will return again this year..

A second curriculum writing workshop will be held to develop suitable hydrogen instructional materials for middle school use. Workshop participants will be local middle school teachers. This team will modify the existing CCC for the middle school audience adding new lessons as appropriate. It is expected that the format for the curriculum will be varied, rather than standardized like the high school product. The differing structures reflect the multiple approaches now concurrently employed in middle school curricula. Because there will be no single approach to the product and formatting may prove complex, it is not anticipated that the beta version of the middle school product will be as complete as the beta version of the high school product.

Once again, the Montgomery and Frederick County Science Supervisors have provided invaluable guidance in formulation of workshop and curriculum strategy. Print articles announcing development of the curricula and the status of ongoing work will be developed this fiscal year.

Live Science Shows

This year's NHA theme was "Setting global standards." The *Dr. Bob Show* reflected this theme by using material from the newly developed high school curriculum, the *Clean Corridor Curriculum*.

The format for the 1999 Secondary School Invitational is representative of past year shows. The stage was set for the *Invitational* by the award winning film, *Renewable Power: Earth's Clean Energy Destiny*. The *Dr. Bob Show* followed, featuring Dr. Bob and his faithful assistant, "Little Jon" Hurwitch from SENTECH. In his capacity as Dr. Bob's sidekick, and with additional SENTECH cast and crew assistance, Jon Hurwitch has consistently provided the support necessary to transform the *Dr. Bob Show* from an interesting amateur science program to a first rate science education performance.

This year there were two demonstrations that "set the standard" for science learning and future technology. The first demonstration was by Drs. Jay Keller and George Thomas from Sandia Livermore. They introduced *Red Thunder*, the remote control fuel cell powered vehicle. For the second demonstration Merit Academy students from California presented a fuel cell powered ice cream maker they developed in cooperation with Schatz Energy Research Center at Humboldt State University.

During lunch an Advanced Placement class from Northwest High School presented the results of their *Hydrogen Filling Station Project*, part of the *Clean Corridor Curriculum* field-test they are participating in under the direction of Mr. George Smeller. Mr Smeller was Co-Team Leader for development of the *Clean Corridor Curriculum*.

After lunch the students were divided into smaller groups to participate in a series of three rotations:

the *Dr. Bob Laboratory*, where students experienced more hands-on science with Dr. Bob cast and crew;

the *Learning Center*, where students visited multiple special *Invitational* displays including:

- a fuel cell hardware display and demo by DAIS Corporation;
- a DCH demonstration of hydrogen technology sensors;
- a demonstration and mini-lecture by Dr. Michael Seibert on photo-biological hydrogen production and applications;
- Ahands-on@exposure to the remote control fuel cell car and fuel cell powered ice cream maker.

the NHA Exhibit Hall and parking lot, site of live fuel cell vehicles.

The afternoon concluded with the career panel *COOL*, Career Opportunities of a Lifetime and a brief awards ceremony.

Again this year, Dr. Bob and the live Science Show returned to a local middle school, the same school we had visited last year. The head of the science department reported that the school led its county last year in standardized science testing following the *Dr. Bob Show*. We hope for similar results this year.

Both shows were filmed. They are now being edited. Post-production work, scheduled for this summer, will meet local cable TV programming and format standards.

Promotion and Product Branding for Instructional Materials and Live Science Shows

Serious promotion occurred of Hydrogen Education Outreach occurred at several conferences this year:

MAST - the Maryland Association of Science Teachers

The entire *Clean Corridor Curriculum* Team presented a workshop at the annual conference.

NSTA (National Science Teachers Association) Annual Conference in Boston

A full-scale exhibit showcased the *Clean Corridor Curriculum*, bolstering the effort to recruit teachers for the field-test and generate longer term interest in continued learning about Hydrogen Outreach and our curriculum products.

Maryland Eisenhower Conference

I presented the curriculum and the larger Hydrogen Education effort to a full house of Maryland science teachers attending the state-s premier science education conference.

ChemEd Biennial Conference

This biennial conference will offer serious opportunities to present the curricula and network with secondary school chemistry teachers from across the nation.

Efforts to brand our products to build awareness and preference in the education community are also underway. The working brand name of the hydrogen education outreach products is *HIP*, for hydrogen instructional programming. While this may not be the ultimate brand name, a branding process will be undertaken to facilitate the marketing and distribution of our products.

Future Work

Live Science Shows

Live science shows will continue. The *Dr. Bob Show* will continue to be the main attraction, whether as part of the *Secondary School Invitational* in conjunction with the annual NHA Conference or as a stand alone event at local middle schools.

Any live show offers the filming opportunities. With the FY-99 footage, it is expected that a *Dr. Bob Show* program(s) will be produced for broadcast by local cable. Future production opportunities include:

- major cable production(s), i.e., for state public television and e.g., for Discovery;
- a video with professional actors (discussions are underway with Beakman and his agents) for education and training, rather than broadcast purposes;
- a film for broadcast.

The top two production possibilities have been included in a proposal for FY2000 Education Outreach funding. The third proposal, though a worthy and logical complement to the suite of film products, is currently beyond the scope of available funding.

Instructional Materials

There is yet one other film piece slated for production in FY2000, and that is the video-clip of *Red Thunder*. This video-clip of the Hydrogen Education Outreach's remote control fuel cell vehicle has multiple potential audiences, from the classroom to the conference room and the greater DOE/EE library. However, the remote control fuel cell vehicle is so closely identified with the curriculum and so compelling as an engagement piece, that its first allegiance is to the body of instructional material rather than the suite of film products. This is likely to remain so until the Hydrogen Education Outreach activity can devise a method of making a remote control hydrogen vehicle (already assembled or needing assembly) on a cost-effective basis.

The marvelous existing hydrogen film resources -- *Element One* and *Renewable Power: Earth's Clean Energy Destiny* -- will be incorporated in the curriculum offering to the extent that copyright and contractual arrangements for these films permit.

Future plans for instructional materials include field-testing and evaluation for the

middle school curriculum scheduled for development in FY=99 together with additional field-testing of the revised *Clean Corridor Clean*. The latter is expected to occur at least partly in the context of teacher training. Middle school teacher training would occur in the year following the middle school field-test and evaluation.

Future instructional products are expected to include a curriculum to teach education majors. This group, often apprehensive at best and science challenged at worst, have been identified by university educators as a prime audience for our instructional materials.

Other future education products include primary school materials at one end, and Amodule size@college products at the other end of the formal education continuum.

Curriculum Dissemination

The selection of an appropriate distribution channel(s) is an important task for future work. It appears likely that some form of web-based distribution will be appropriate. Certainly, the web offers a wonderful promotional tool. However, it is not anticipated that web-based distribution will be the exclusive dissemination method. Rather, some mix of print materials and information technology seems likely.

Challenge Grant

The example of the Merit Academy science project clearly demonstrated what extra funding can do for a science curriculum. While the Merit Academy case is not replicable on even a modest scale with the present level of education funding, it is possible to stimulate some greater Ahands-on@involvement through discreet funding awards. Development of a challenge grant program is expected to provide motivation to teachers to undertake hydrogen related projects. Funding is expected to range from small awards of ~\$250 to a maximum of \$2500.

Dream Project

While the current cost of *Red Thunder* makes it appear unlikely that a remote control fuel cell kit could be successfully developed and marketed as part of a deluxe Ateachers kit,@the possibility will be explored through careful market research. As a perfect complement to the curriculum, the remote control fuel cell vehicle might ideally be made available to every interested science classroom in America.

Current and Future Work

As in the past, team building will be critical to progress. Likewise, collaborations are expected to be key to many Education Outreach tasks: new product development, evaluation, promotion and distribution. Distribution is not expected to be easy. The Hydrogen Education Outreach activity will seek to actively cooperate with the EERE EnergySmart School Initiatives and other established commercial channels. The mix

of abstract (Information Technology) and concrete (print materials) products has been found to be appealing. Both have a place in the HIP portfolio of hydrogen education outreach products.

Expected Impact

The *Clean Corridor Curriculum* and its collateral products are unique and fill an unmet need for hydrogen education. There are three major end-user education markets: students, teachers and parents.

The Department of Education reports that as of 1994, 56% of high school graduates took chemistry, while 93.5% took biology and 24.4% took physics. At a 56% rate, the estimated size of the student population taking chemistry would be between 1.6 and 2 million students per year. A conservative 1% market penetration rate would expose some 160,000-200,000 high school graduates per year to hydrogen, stimulating awareness and understanding of uses and technologies, promoting and accelerating early adoption in the marketplace.

1998 National Science Teachers Association (NSTA) membership includes 720,000 teachers and estimates the universe of K-12 teachers at two million nationwide. The NSTA survey extrapolates to a universe of approximately 200,000 total high school science teachers and an estimated 54,000 chemistry teachers nationwide. This group represents a primary market for the CCC.

Finally, there are the parents. Averaging two parents per student yields double the number of students estimated to experience greater hydrogen awareness (and perhaps preference) as a result of Hydrogen Education Outreach instructional materials.

The expected impact of hydrogen films cross-cuts formal and informal education outreach opportunities. With respect to film Viewership, potential for the local cable production exceeds 800,000. VIEWERSHIP potential for the Maryland Public Cable Station. is estimated at ~5 million. Finally, films are expected to make a handsome and very usable addition to the EERE and DOE resource libraries.

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