WIP: A Pilot Study to Assess the Impact of a Special Topics Energy Module on Improving Energy Literacy of High School Youth

Jan DeWaters[1] and Susan Powers [2]

***Abstract* – An energy education program that embeds energy topics within a societal context that is meaningful to students may improve energy literacy and effectively prepare students to interpret energy issues and make sound actions and choices as voters, consumers, and professionals. High school environmental science students participate in a project-based energy module where they explore technical, environmental, societal, and economic concerns related to the production, delivery, and use of hydrogen fuel and fuel cells for transportation. In-depth assessment evaluates the course's impact on students' energy-related knowledge, attitudes, and behaviors, as well as their feelings of general self-efficacy. The analysis uses a triangulated mixed-methods design, including pre/post written questionnaires, classroom observations, post-program focus group interviews, and post-program opinion surveys.**

Index Terms – Energy education, Energy literacy, Hydrogen fuel cell, Project-based learning, Societal context.

INTRODUCTION AND BACKGROUND

Environmental issues, and energy-related issues in particular, play a prominent role in the lives of today's students. As we move into a future with limited fossil fuel resources and worsening environmental conditions, our society is becoming increasingly entrenched in a struggle to define new directions with respect to energy consumption and energy independence.

Energy literacy enables people to embrace appropriate decisions and behaviors with respect to energy in everyday life. An informed public will be better equipped to make responsible energy choices. Unfortunately, recent evidence suggests that U.S. students – in fact, the U.S. public in general – are lacking in their awareness of energy-related issues [1]-[4]. The National Environmental Education & Training Foundation (NEETF) found in a 2001 survey that, while many Americans tended to overestimate their energy knowledge, just 12% could pass a basic quiz on energy knowledge [2].

Energy education typically falls within the realm of science instruction in the traditional K-12 curriculum. Curricular-based topics generally include scientific principles associated with energy concepts – energy conversion, work, and power. A variety of alternative materials have been developed that address energy issues from a broader perspective, but many of these are still primarily concerned with the scientifically based energy concepts that are embedded in the requirements of State and National education standards. Few address students' attitudes or behaviors related to energy issues, and the implications of those attitudes and behaviors within a societal or global context. Moreover, most are available as *supplemental* science activities. Experts generally agree that the best way to promote energy literacy is to include energy education within the existing curricula and, where possible, to use an interdisciplinary approach [5]. A project-based approach that provides opportunities for learning within an overarching problem assignment, with reference to societal themes, makes the material more relevant to the students' own lives and helps them understand how the science impacts them and the communities in which they live.

PROPOSED STUDY

This descriptive study evaluates the impact of a special topics energy module on students' energy-related knowledge and attitudes. "The Hydrogen Economy" is an 18-day module created and taught in conjunction with an NSF GK-12-funded educational outreach program at Clarkson University. Throughout the interdisciplinary module (Table I) students explore technical, environmental, societal, and economic concerns related to the production, delivery, and use of hydrogen fuel and fuel cells for transportation. The module is framed within a societal/global context and is project based: students are first introduced to their problem assignment, and all subsequent activities and investigations are designed to provide them opportunities for gaining knowledge and skills needed to complete the assignment. An element of formalized decision making instruction has been included [6].

The study is piloted in a high school environmental science class (18 students), with plans to expand the program into additional high school science classrooms in the future. Through the pilot study we hope to evaluate the effectiveness of the learning module (e.g., classroom delivery) and the study design (evaluation and analysis). The evaluation will assess the module's impact on students' general knowledge and awareness of energy issues, their energy-related attitudes and behaviors, and their general feelings of self-efficacy and locus of control (LOC). We will also correlate energy knowledge,

[1] Jan DeWaters, Graduate Student, Clarkson Center for the Environment, Clarkson University, dewaters@clarkson.edu
[2] Susan Powers, Associate Dean for Research & Graduate Studies and Professor, Civil and Environmental Engineering, Clarkson University, sep@clarkson.edu

attitude, behavior, self-efficacy, and LOC among students, pre- and post-program. Analysis will use a triangulated mixed-methods design, using both quantitative and qualitative methods for data collection and analysis. Quantitative results will be compared with qualitative data to corroborate statistical trends and provide a deeper explanation of findings.

TABLE I
ENERGY MODULE: THE HYDROGEN ECONOMY

Introduction
Students are introduced to hydrogen fuel cell cars and their assignment: **Teams of students will prepare advertisements and compete for General Motors marketing firm contract to sell their new hydrogen fuel cell car.**
Why do we need alternative fuels?
Students use a combination of laboratory activities and literature investigation to explore problems associated with fossil fuel combustion. Students calculate their Transportation Carbon Footprint.
How does a fuel cell work?
Students build and test a model fuel cell, and create H_2 through electrolysis.
Where does the hydrogen come from?
Debate and decision-making strategy exploring pros and cons of different methods of hydrogen production. How do different production technologies impact overall well-to-wheels CO_2 emissions?
Other issues: creation of a hydrogen infrastructure
Students propose a hydrogen production and delivery scenario for their geographical area.
Presentation of final projects
Marketing teams present final advertisement for Hydrogen Fuel Cell Car. Additional individual reports on environmental, technical, economic, societal impacts of hydrogen economy are delivered for portfolio assessment.

The quantitative component uses a single-group pre-test/post-test design with the pre-test acting as the control group. Students complete written energy surveys and self-efficacy scales one month before and shortly after their experience with the program. The survey combines knowledge, attitude, behavior, and LOC questions. The energy survey is a modified version of the Test of Energy Concepts and Values (TECV), which was developed in the 1980s to investigate energy knowledge and attitudes of 9th grade students [7]. Self-efficacy is measured using a 10-item general self-efficacy scale that is recommended for persons ages 12 and up [8].

The qualitative methods are guided by a concern over how the course has changed students' energy-related attitudes and behaviors, both on a personal and a global scale, and how the students view the effectiveness of their own actions toward making an impact on global and local energy issues. Qualitative procedures will consist of classroom observations (minimum 3X), post-program focus group interviews with students (six students of all abilities), exit interview with teacher, and post-program written opinion surveys administered to students, parents, and teacher.

DATA ANALYSIS

Changes in energy knowledge, attitudes, and feelings of self-efficacy will be evaluated using paired sample t-tests to determine significant pre-post differences in questionnaire responses. Likert-scale responses to attitude and behavior questions will be further analyzed for frequency distribution changes pre/post. Aggregated class data will be used to investigate changes in group response to particular questions or groups of questions, while individual student responses to the aggregated questions will provide information regarding general knowledge, attitude, behavior and self-efficacy changes among the students as individuals.

Interview transcripts and post-program free-response survey data will be analyzed using inferential statistics. Materials will be reviewed for the presence of patterns revealed by the narratives that may expose inconsistencies or further explain the quantitative results. Patterns will be identified and tabulated, and subsequently quantified according to the frequency, extensiveness, and intensity of response.

PROJECT STATUS AND SUMMARY

This pilot study is scheduled to occur in late May/early June of 2006. Preliminary analysis of student pre-survey questionnaires, completed in April 2006, reveals that student performance on the attitude portion of the survey was generally better than the knowledge and behavior sections. Students scored a mean of 59% on both the knowledge and behavior portions of the test, while the mean attitude score was 72%. Perhaps this indicates that, while students have the desire to make appropriate energy choices, they lack the knowledge to do so. An initial round of pre vs. post data analysis will be complete for presentation at the conference.

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