Using a Real-world, Project-based Energy Module to Improve Energy Literacy among High School Youth[1]

Abstract

A project-based energy module has been taught for five consecutive years in a high school environmental science class as part of an NSF GK-12 outreach program. The module brings students through an exploration of problems and potential solutions related to automotive transportation, a relevant topic for the average American teenager. Students investigate problems related to our current fossil fuel based transportation system including environmental impacts and limited fuel supplies, and explore potential solutions that include alternative modes of transportation and fuels as well as lifestyle changes. Changes in students' energy literacy, a broad term that includes a citizenship understanding of energy issues as well as attitude and behavioral aspects, have been assessed over the last three program years using a quasi-experimental, mixed methods approach that includes both quantitative and qualitative measures. The quantitative measure consists of a written Energy Literacy Survey that has been developed and validated as part of this research. Qualitative data, collected through a combination of questionnaires, focus group interviews, and classroom observations, add depth and understanding to the quantitative results. Analysis of the quantitative survey over three consecutive years indicates that students show significant improvement in energy-related knowledge (scores increased from 60% pre to 68% post), feelings of self-efficacy related to energy issues (71% pre to 75% post), and energy consumption behaviors/intentions (63% pre to 69% post). Similar gains reported by a comparison group, available for only one study year, indicate that students may be influenced by experiences outside the classroom and point to the need for additional data to clarify the results. When asked to self-assess their learning, 84% of the students said they learned a lot or a quite a bit about energy issues. Responses to open-ended questionnaire items indicate that the course increased (81% of the) students' awareness of the need to conserve energy; 54% indicated that they are more aware of the implications of their own energy use on the overall energy problems; 20% say they are more aware of, and troubled by, Americans' overconsumption of energy resources; and 60% reported positive changes in their energy consumption behaviors. These preliminary results suggest that the project-based curriculum is effective for promoting student learning, but the generally low knowledge scores indicate the need for continued efforts toward wider implementation of energy education programs.

Introduction

Energy issues are inarguably the most hotly debated topics in today's world. As we move toward a future with dwindling 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, which includes broad, citizenship knowledge as well as attitudinal and behavioral aspects, will enable people to

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embrace appropriate decisions and behaviors with respect to energy in everyday life. An informed public will be better equipped to make responsible energy choices and actions.

A number of surveys have shown generally low levels of energy knowledge and awareness among U.S. students and the general public.[1-7] For example, 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.[3] More recent surveys indicate that consumers are becoming more aware of renewable energy resources, but remain confused about many other issues such as the main areas of energy consumption within their homes and communities.[4, 7]

Effective educational programs will make strides toward improving energy literacy. This paper describes our implementation and evaluation of a special topics energy module in a High School Environmental Science class. The project draws from educational research data that show the benefits of using project-based or inquiry-based approaches to improve student understanding and retention of content matter,[e.g. 8, 9] as well as ideas from proponents of STS (Science-Technology-Society) education, who maintain that embedding scientific topics within a societal context will help students become engaged because they realize the relevance of the material to their own lives.[e.g. 10-13]

The objective of this research is to evaluate the benefits of a special topics energy module for improving students' energy literacy. The module is project based and centers on a real world problem that is relevant to students at the high school level. Our assessment combines results from three years of quantitative and qualitative data collection and interpretation. Benefits are measured in terms of students' improvement in broad energy-related knowledge and awareness, improved attitudes and feelings of self-efficacy toward energy-related issues, and increased energy conservation behaviors and intentions.

Methods

<u>The Course</u>

The HS Environmental Science energy module brings students through the exploration of technical and societal-based issues surrounding energy production and consumption as they work their way through the solution of a real-world problem related to an energy issue – modes of private vehicle transportation. The module was developed and modified by graduate students from Clarkson University with the support of an NSF GK-12 grant. The energy module was designed based on themes from STS and project-based learning models of instruction, and contains elements of instruction and practice in formal decision making. Module content is correlated to New York State (NYS) and National Learning Standards for Science, Mathematics, and Technology, with a focus on science inquiry and the "extended process skills" covered by NYS Standards 1, 2, 6, and 7:

- Standard 1 - Analysis, Inquiry and Design. *Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.*

- Standard 2 - Information Systems. *Students will access, generate, process, and transfer information using appropriate technologies.*

- Standard 6 - Interconnectedness: Common Themes. *Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.*

- Standard 7 - Interdisciplinary Problem Solving. *Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.*

The energy module, which has been taught (with several variations) for the last five years in a high school environmental science classroom, requires students to investigate the feasibility of various propulsion/fuel system technologies for use in vehicular transportation, including for example hydrogen fuel cells, biofuels with internal combustion engines, and electric cars. As shown in Table 1, the specific questions posed to the students and the final deliverables have changed throughout the years to most accurately reflect current and relevant transportation fuel and vehicle issues in the news. For example, in President G.W. Bush's 2003 State of the Union address, he promoted the concept of the Hydrogen Economy, while in the 2007 State of the Union address he proposed that the solution to reduce our dependence on foreign oil for transportation fuels had shifted to biofuels, with a goal of producing 35 billion gallons of renewable fuel a year by 2017. Both of these future transportation systems are integral within this module.

Table 1: Projects completed in the HS Environmental Science Energy Module[a]

Year	Situation/Question posed
AY05	Imagine it's the year 2010, and the residents of Potsdam have to vote on a referendum that has come up: "To reduce harmful exposure of children to emissions from diesel buses and reduce consumption of fossil fuels, the School District wants to convert their bus fleet to hydrogen fuel cell buses. A state grant is available that will limit the cost of this project to $200/per family." Prepare a report and presentation to justify how you would vote on this referendum.
AY06 (May 06)	General Motors is hiring a marketing firm to help sell their new Hydrogen Fuel Cell car. Teams of students will compete for the job with the selection based on a final presentation of their advertisement, as well as demonstration of a thorough knowledge of technical, environmental, economic, and societal implications of the new technology. Students will be required to prepare and present an "advertisement" that communicates necessary information to consumers.
AY07 (Jan 07)	With the uncertainty that new technology brings to the marketplace, GM has reason to hesitate about bringing new car technologies to the market. Should they really go forward with the fuel cell car or should they manufacture a battery electric vehicle? As an advisory group to GM, it is your goal to make a convincing argument for or against one of these technologies.
AY08 (Jan 08)	The United States of America Forum on Sustainable Transportation will be convened to address issues associated with personal transportation. What will the car of the future look like, what will power it, or will we even have personal vehicles? Your class will divide into teams to create a platform for sustainable transportation. Each team will present their platform and the class will hold representative elections to define the best platform for our future transportation.
AY09 (Nov-Dec 08)	Issues surrounding our fossil fuel based transportation system, including environmental impacts, limited fuel supplies, and increased economic burden, have inspired the development of new vehicles. Many of these are powered by new types of engines and a variety of fuels, making it difficult to compare energy use in terms of our traditional "miles per gallon" standard. Develop a new way to compare the fuel consumption that makes more sense in our changing society and transportation choices.

Regardless of the variation in actual project assignment, the energy modules have all been taught in a project-based mode, starting with understanding the problem and finishing with the justification of a recommended solution. The students are introduced to their problem, or "guiding question," at the beginning of the course, and all activities performed throughout the module are designed to provide them with the knowledge and skills they need to fulfill the assignment. The unit is interdisciplinary (integrating science, math, technology, writing and communication) and approaches the investigation and application of new automobile technologies and transportation fuels within a societal and global context. Table 2 summarizes the general outline of the course, which follows a standard engineering problem solving approach. In any given year, the specific details have varied within this framework. The entire module is designed to extend over a total of 16 to 20, 40-minute class periods. Detailed unit and lesson plans for this module are available.[14]

Participants
Students enrolled in an advanced placement environmental science (APES) class at a high school in rural St. Lawrence County, NY have been study participants for all three years. This non regents-based science course provides the opportunity for advanced college credit, and attracts students from multiple grade levels and a range of academic abilities, usually with a higher concentration of college bound students. The energy module has been taught as a special session within this course, with instruction primarily provided by a graduate student funded through Clarkson University's NSF-GK12 Project-based Learning Partnership Program.[15-17] This program brings graduate and advanced undergraduate engineering and science students from Clarkson and St. Lawrence Universities into local middle and high school classrooms to teach project-based learning modules. The high school students in this course provided a sample of convenience, in that participants were not randomly selected, but participated involuntarily by virtue of their presence in the classroom. Students enrolled in the course with no prior knowledge about the energy unit or the proposed study. The sample size was 39 students total (17, 11, and 11 in AY07, AY08, and AY09, respectively).

Table 2: H.S. Energy Module follows a Standard Engineering Problem Solving Process

General problem introduction	o Background - transportation, vehicles, fuel consumption, other impacts o Class project introduced
Detailed analysis of problem	o Research activity - by groups on various impacts (fossil fuel depletion [peak oil] , vehicle fuel economy, air pollutants, polar ice cap size, CO_2 concentrations, global temperatures) o Carbon footprint activity

Identification of potential solutions	o Cars of the future introduction
	o Hydrogen fuel cell vehicles
	  ▪ How they work – two fuel cell construction activities
	  ▪ Where hydrogen comes from – electrolysis activity
	o Electric vehicles
	  ▪ Batteries and battery activity
	o Biofuels
	  ▪ Biofuel options
	  ▪ Making biodiesel activity
	  ▪ Heat of combustion of biofuels activity

Assessment of potential solutions	o Energy efficiency activity o Lifecycle perspective activity
Selection of recommended solution	o Work days o Final presentation / debate / debrief

Students enrolled in an advanced placement biology class at the same high school comprised the comparison group. The make up of this class is very similar to that of the APES class: students are from multiple grade levels and academic backgrounds, again with a concentration of college bound students. The comparison group consisted of 20 students in AY08.

Data Collection and Analysis

The study used a quasi-experimental, triangulated mixed methods design, employing both quantitative and qualitative methods for data collection and analysis (Table 3).[18, 19] Quantitative data were collected using a written survey instrument, administered pre/post the special topics energy course and similarly administered to a comparison group pre/post their regular standards-based science program (full pre/post comparison group data are available for AY08 only). The quantitative instrument is the Energy Literacy Survey, [20, 21] developed and validated as part of this research and available from the authors by request. The survey has been designed for classroom administration and uses a combination of multiple choice and Likert-type summated rating scales to address four measures of students' energy literacy - energy-related knowledge (38 items), attitudes toward energy issues (13 items), feelings of self-efficacy (4 items, contained within the attitude subscale), and energy consumption behaviors and intentions (10 items). Questions contained in the Energy Literacy Survey are intentionally broad in nature, and are not intentionally related to the course content.

Table 3: Summary of Data Collection Procedures

	Administered to…				A Measure of…			
Quantitative / Qualitative	Student Participants	Teachers	Parents	Comparison Group	Knowledge	Attitude	Self-efficacy	Behavior
Pre/post Energy Survey	X			X	X	X	X	X
Post Questionnaire	X		X		X	X	X	X
Post Reflective Essay	X				X	X	X	X
Focus Group Discussion	X	X				X	X	X
Classroom Observations	X	X			X	X		

The Energy Literacy Survey was developed according to established psychometric principles and methodologies in the sociological and educational sciences,[22, 23] which involved two rounds of pilot testing, each followed by rigorous item and subscale evaluation. The rational for three separate subscales (with the self-efficacy measure contained within the attitude subscale) was confirmed with factor analysis. Results from a principal component analysis with Varimax rotation (Kaiser normalization) nicely separated the questions into distinct factor groups that

align with topics related to knowledge, attitude, and behavior. Internal consistency reliabilities for the three subscales, measured by Cronbach's α calculated with data from the second round of pilot testing, ranged from 0.75 to 0.83, all sufficiently above minimum acceptable levels (0.70 for a set of items in the social science scales, and as low as 0.60 for scales used in educational assessment).[22, 24] Instrument validation, while best considered an ongoing effort requiring numerous research efforts using the new instrument, has been initially established through a variety of measures: by applying the construct definition (e.g., definition of energy literacy) and reviewing/applying prior energy education and knowledge/attitude/behavior research; by using items drawn from existing energy and environment surveys; and through a survey review process involving a panel of experts in energy and energy education (the "validity panel"). Additional validation has been established by administering the pilot survey to a "known group" of subjects who are literate about energy.

Survey data were analyzed quantitatively using a combination of descriptive and inferential statistics. Changes in energy knowledge, attitudes, self-efficacy, and behavior/intentions were evaluated separately with a paired-samples t test to determine statistically significant pre-post differences. Item responses were converted to numerical scores according to the particular subscale. Likert-type responses in the attitude, self-efficacy, and behavior subscales were converted to numerical values according to a predetermined preferred direction of response, in order to calculate summated rating totals.[25, 26]

The qualitative assessment enhances the study by corroborating statistical trends and providing a deeper understanding of the changes in student response. Qualitative procedures consisted of classroom observations, post-program focus group interviews (AY08 only), reflective essays, and questionnaires that contain a combination of closed- and open-ended questions. In addition to gathering information about students' self-perceived gains in energy knowledge, the qualitative methods have been guided by a concern over how the course 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. Parent questionnaires (AY09 only) provide information about the extent to which students shared their learning at home. Finally, both the study group and the comparison group teachers were interviewed to obtain in-depth information about the extent and depth of energy education in the classrooms.

Results

Because of the relatively small sample size (39 students combined over all three years) and the availability of pre/post comparison group data for only AY08, it is useful to look at results both in terms of overall differences pre/post among the study group (essentially a pre-test/post-test design, with the pre-test acting as the control) as well to compare gains in the study group to gains in the comparison group for AY08. Post-program reflections and questionnaire data have been analyzed over all three study years.

Energy Literacy Survey

Student mean scores on the Energy Literacy Survey, pre- and post-program, are quantified in Table 4 for all three program years combined. Items in the four subscales have been separated

for analysis (self-efficacy questions are distinguished from the rest of the attitude subscale for analysis and reporting). In general, student scores on the cognitive (knowledge) subscale are quite low, both pre and post (mean values pre and post of 0.60 and 0.68, respectively). Scores on the attitude subscale were substantially higher, a finding that is consistent with earlier research.[2, 5, 6] Self-efficacy and behavior scores were higher than knowledge, but not as high as general attitude scores. This progressive decline in student scores, from attitude to self-efficacy to behavior, is understandable if we consider the nature of the items in these scales. For example, it may be easier for a student to indicate strong or moderate agreement with a generalized attitude statement such as "Americans should conserve more energy," as compared with a personalized self-efficacy statement like "I believe I can contribute to solving energy problems by making appropriate energy-related choices and actions." Agreement becomes even more difficult when we move toward statements that reflect actual behaviors, such as "I turn off my computer when it's not in use." Still, the relatively high attitude scores compared with those in the behavior and knowledge subscales seem to indicate that these students hold views that embrace the significance of the energy problems we face, yet they may lack the appropriate knowledge to take effective action toward a solution.

Table 4: Student Scores, Energy Literacy Assessment Survey[a]

Subscale	Pre Mean ± StDev[b]	Post Mean ± StDev	Gain Mean ± StDev	p value[c]
Knowledge	0.60 ± 0.14	0.68 ± 0.12	0.084 ± 0.075	<<0.0001
Attitude	0.80 ± 0.10	0.81 ± 0.10	0.014 ± 0.090	0.177[d]
Self-efficacy	0.71 ± 0.18	0.75 ± 0.15	0.043 ± 0.112	0.014
Behaviors/Intentions	0.63 ± 0.17	0.69 ± 0.17	0.052 ± 0.092	<0.001

[a]n=39 students, combined AY07, AY08, and AY09.
[b]Standard Deviation
[c]Statistical significance of pre-post gain calculated with paired-sample, 1-tailed t test.
[d]Not statistically significant.

As the data in Table 4 indicate, students exhibited significant gains ($\alpha = 0.05$) in energy-related knowledge, feelings of self-efficacy, and behaviors/intentions. There was no significant change in students' general energy-related attitudes, yet the initial scores were relatively high (0.80) so there was not much room for improvement. Even without a significant improvement or gain, the average value of the post attitude scores remained higher than post-scores on the other subscales.

Although scores on the knowledge subscale remained lower than the other subscales both pre and post, the gains in student knowledge were greatest. In fact, scores for individual program years (Table 5) reveal that the gains in knowledge scores for each program year were significant even with the very small sample sizes. The only other significant gain in an individual year was in self-efficacy scores during AY07, when the scores on the pre-survey were quite low relative to other program years.

Another interesting finding from the data shown in Table 5 is the general upward trend in student scores on all survey subscales over the three program years, both pre and post. Reasons for this are only speculative and could be related to changes in the student population taking the course as well as general changes in the types and amounts of energy-related information to which students are exposed throughout their lives. The likelihood of this latter possibility is a very real scenario, given the general increase in energy topics in the media such as rising fuel costs, changes in the automotive industry, and implementation of alternative energy systems.

Table 5: Student Scores over Individual Program Years

	Mean score (pre)			Mean Score (post)			Average Gain		
Program year	AY07	AY08	AY09	AY07	AY08	AY09	AY07	AY08	AY09
Knowledge	0.51	0.64	0.63	0.59	0.72	0.74	**0.08[a]**	**0.06[a]**	**0.11[a]**
Attitude	0.74	0.81	0.83	0.77	0.83	0.85	0.03	0.02	0.02
Self-efficacy	0.60	0.79	0.80	0.68	0.76	0.84	**0.08[a]**	-0.03	0.04
Behaviors/Intentions	0.61	0.72	0.72	0.60	0.76	0.76	-0.01	0.04	0.04

[a]Gain is significant at $\alpha = 0.05$.

As with any educational study, there are a wide range of influential factors beyond the classroom that may contribute to student changes. Recognizing the prevalence of energy issues in the media, and the general trends shown in Table 5, it becomes particularly difficult to attribute significant gains in student scores solely to their experiences in the classroom. The impact of the course itself on students' energy literacy scores is more reliably described by comparing the results of the study group with those of the comparison group. Table 6 presents the changes in mean scores for both groups for AY08, the only study year thus far for which such data are available (AY09 post survey data for the comparison group will be available in June 2009). As shown in Table 6, there was no significant difference between the changes pre/post of the study group as compared to the control. Thus, from the quantitative survey data alone, we can

Table 6: Student Gains, Study and Comparison Groups in AY08[a, b, c]

	Average Gain, Study Group	Average Gain, Comparison Group
Knowledge	0.06 ± 0.06	0.06 ± 0.08
Attitude	0.02 ± 0.06	0.03 ± 0.06
Self-efficacy	-0.03 ± 0.12	0.04 ± 0.13
Behaviors/Intentions	0.04 ± 0.07	0.05 ± 0.06

[a]Data are mean gain ± standard deviation, presented for AY08: study group n=11; comparison group n=20.
[b]Statistical significance is a test of the difference in gains between the study group and the comparison group, calculated with a type 2 (unpaired sample), 1-tailed t test.
[c]None of the differences were significant at $\alpha = 0.05$.

conclude that there was indeed a significant gain in students' energy-related knowledge, behavior, and feelings of self-efficacy, yet we can not conclude that this gain is solely because of their experience in the energy module. Of notable importance is the very small sample size used in this analysis, which likely contributes to the lack of a significant finding. Additional data from the current study year, once obtained, will be used to help clarify the findings.

Post-program Evaluations

Student responses to post-program questionnaires, focus group discussions, and reflective essays help elucidate the degree to which the course contributed to their changes in energy literacy, because they are given a chance to describe in their own words how the course has changed the way they think and feel. Student responses on post-program questionnaires are summarized quantitatively for the three combined program years in Figure 1 with year-by-year details in Table 7. The vast majority of students found the module interesting and relevant to their own lives and felt they learned a lot or a quite a bit about the energy topic covered as well as energy issues in general (84% of the students, overall, responded positively – definitely yes/yes, or learned a lot/quite a bit – to statements concerning these program aspects).

Table 7: Student Responses to Post-program Questionnaires

Statement	Percentage of Students who Responded Positively[a]		
	AY07	AY08	AY09
1. I found the topic interesting.	82	69	100
2. I found the topic relevant to my own life.	87	75	91
3. How much did you learn about the specific energy topic you studied?	82	82	91
4. How much did you learn about other energy-related issues, not necessarily related to the specific topic we studied?	75	82	100

[a]Positive response is "definitely yes" or "yes" for questions 1 and 2, "a lot" or "quite a bit" for questions 3 and 4.

An overview of the student reflective essays and post-questionnaire items is summarized below. Because the post-program questionnaires addressed different aspects over the three study years, the statements below refer parenthetically to the particular year the issue was addressed.

➢ 45% of students (AY09) indicated that they talked more with their families about energy issues after taking the course. Parent surveys verified this finding: out of five returned surveys (42% response rate, AY09 only), four parents responded that their son/daughter discussed the energy course at home, and three indicated that their student related helpful information and seemed more interested and concerned about energy issues and energy consumption. One parent reported that her daughter encouraged the family to switch over to energy saving (compact fluorescent) light bulbs.

➢ 81% (AY07, AY08, AY09) wrote that the course increased their awareness of the energy problem, negative impacts related to energy use, and the need to conserve energy. Seven students reported specifically that they were more aware that, as Americans, we consume too much energy and create too much waste.

➢ 54% (AY08, AY09) expressed an increase in feelings of self-efficacy, agreeing that their actions and behaviors as individuals can help solve problems related to the energy situation (limited fossil fuel supplies, environmental impacts from production and use). "(The course) convinced me that our individual actions do affect the world as a whole and energy conservation should be taken seriously…"

➢ 81% (AY07, AY08, AY09) expressed their willingness to assume responsibility for solving energy problems instead of leaving them for future generations (students agreed that it is [completely or mostly] their generation's responsibility to solve the energy problems that face our world). Students commented that it's "our responsibility," the "sooner the better," and two students expressed hope that we "do this now, before fossil fuels run out."

➢ 20% (AY07, AY08, AY09) claimed they were more aware of, and more troubled by, Americans' overconsumption of energy. One student commented that the course "made me realize the impact of my own energy consumption." In their reflective essays, roughly half the students mentioned that they are more aware of their own energy consumption. "The project made me much more aware of what I do in the world."

➢ 60% (AY07, AY08, AY09) reported positive changes in their energy consumption behaviors (increased efforts to conserve energy). "I'm much more observant about what I use and how much I consume/waste" … "I am surprised to see how much I have applied [this learning] to my everyday life."

➢ A full 55% (AY07, AY08, AY09) reported making an effort to use less energy through such specific actions as driving less/walking or carpooling more, switching light bulbs in their household to compact fluorescents, recycling more, using less water, and being more cognizant of turning off lights and appliances when not in use.

One student expanded about the way the course influenced her overall motives for saving energy: "Before, I would limit driving because I didn't want to waste money for gas … but now it is a different motive. I understand the effects of driving a car even just one mile. The amount of energy needed just to put the fuel in my car, the quantity combusted, and the emissions … are significant even if it's just for one mile."

Students in the post-program focus group interviews (AY08) generally described how the course made them more aware of the wastefulness of our lifestyle and the severity of the need to change. They described taking small steps toward saving energy such as riding their bike or walking more, taking shorter showers, and recycling. In general the overall feeling was that awareness was increased and they are more keen to current events in the news. They also expressed a desire to learn more about specific ways they can take action toward solving energy problems.

In summary, then, it appears that the students did realize significant gains in energy literacy levels, and according to their reflections and their self-assessed changes, much of these gains can be attributed to their experiences with the energy module.

Conclusions, Implications

Students who have participated in a real-world, project-based energy module have shown significant gains in their energy-related knowledge, attitudes, and behaviors/intentions, as measured by a quantitative Energy Literacy Survey administered pre/post the energy unit. Student gains in cognitive knowledge about broad energy topics, not specifically covered in the curriculum, indicate that the course is making them more aware of energy issues within their own lives outside of school, a finding that is corroborated by student responses to open ended post program evaluations. In general, this increase in overall awareness seems to be the most pertinent impact of the course.

The lack of significant differences between findings among the study group and a comparison group may indicate that students are influenced by exposure to energy-related topics outside of the classroom, a possibility that is quite likely in today's world. Lack of sufficient sample sizes has limited our ability to clearly distinguish between these effects; additional data obtained from the current program year, once ready, may help to clarify these results.

Although student knowledge increased after taking the course, the relatively low mean scores indicate a continued lack of broad, energy-related knowledge. Scores on the behavior/intention scale were somewhat higher, and attitude scores higher still. In fact, the relatively high mean scores on the attitude subscale pre-program as well as post-program indicate that students are indeed cognizant of and sensitive to the energy problems we face as a nation, a community, and as individuals, but they lack the knowledge to take effective actions to help remedy the situation. Students expressed in post-program focus group interviews that they would benefit from educational programs that provide them with more skills to actually make a difference. Overall the results of this research support wider implementation of project based energy education programs for improving students' energy literacy.

Acknowledgements

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