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Environmental Energy Course Adopted into a University's Core Curriculum

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Abstract

Most people are aware of the global energy challenges of pollution, greenhouse gas production, dwindling nonrenewable resources, and the environmental consequences of resource exploitation. Although recognition of these problems is widespread, many studies have shown that America's "energy literacy" rate is low. This article describes the development and execution of an introductory environmental engineering course offered to nontechnical students to address the problem of low energy literacy. Previous studies classified energy literacy into three domains: cognitive, affective, and behavioral, and concluded that effective energy education should target knowledge *and* values. As engineering faculty, the authors believe that a technically literate public is crucial to the development of rational energy policies. A course on energy was developed for nontechnical students with majors including accounting, architecture, mathematics, chemistry, education, biology, business, criminal justice, political science, and history. The course has been adopted into the university's core curriculum, satisfying the objective for scientific literacy in natural sciences. It is the first general education offering from engineering faculty.

Challenges in the development of this course included attaining the right balance between qualitative and quantitative material and tempering faculty's enthusiasm for rigorous mathematical analysis in deference to a nontechnical audience that largely reflects the region's diversity. The overriding goals were to inform students about energy production and consumption patterns, various technologies and their environmental consequences, and the pros and cons of renewable and nonrenewable energy systems. Other objectives were to provide a straightforward yet sophisticated appreciation of the negative effects of unconsidered energy consumption, a knowledge of the physical laws governing and technologies behind conventional and alternative energy production, and an array of tools to evaluate and implement energy conservation strategies on personal and corporate levels.

To achieve these objectives, several projects were implemented calculating heat usage and heat loss during a winter month for a campus building, performing energy audits for the residences in a neighbouring community and calculating estimated energy savings. In addition, a term paper researching atmospheric pollution and its sources and effects was required. This activity helped students gain a deeper appreciation of the impact of energy-related choices, behavioral actions, and human activities, as well as the price of technological advances and modern lifestyles on the environment.

The instructors wanted to gauge the effectiveness of the class on the students' energy literacy. Questions from the NEETF report were chosen, allowing for a comparison between student and national responses. Survey questions were divided into those addressing knowledge, attitude, and behavior. Results from pre- and post-course energy questionnaires indicate that the course was effective in improving student energy knowledge and awareness of important energy issues.

Keywords: energy literacy, core curriculum, course development, service learning

Background

Motivation for the course

Most people are aware of the global energy challenges of pollution, greenhouse gas production, dwindling nonrenewable resources, and the environmental consequences of resource exploitation. Although recognition of these problems is widespread, many studies have shown that America's "energy literacy" rate is low. A 2002 report by The National Environmental Education & Training Foundation (NEETF 2002) indicated that "just 12% of Americans can pass a basic quiz on energy knowledge," and that misconceptions about energy abound. For instance, only a third of the respondents knew that most of our electricity comes from burning coal, and only 40 percent understood that conservation, as opposed to oil exploration and building new power plants, is the quickest way to decrease energy use. Similarly, surveys of secondary school students found that "while students may recognize the existence of an energy problem, they generally lack the knowledge and capabilities to effectively contribute toward a solution" (DeWaters and Powers 2008), and that energy literacy levels are "discouragingly low" among New York State middle and high school students (DeWaters and Powers 2011).

Kandpal and Garg (1999) noted that while in the past an abundance of cheap energy caused society to view energy simply as a commodity and not worthy of its own educational discipline, contemporary global issues beginning with the 1973 oil crisis and continuing with increasing evidence for climate change have produced a need for the development of curricula for energy education. DeWaters and Powers (2011) classified energy literacy into three domains: cognitive, affective, and behavioral. Emphasizing that energy literacy encompasses not only technical and scientific knowledge, but also values and attitudes (the "affective" domain) and habits and practices (the "behavioral domain"), they concluded that effective energy education should target knowledge *and* values, asserting that this combination would result in more responsible energy-related actions. Dias et al. (2004) stated that barriers to efficient energy use include institutional, market, organizational, and behavioral concerns. They asserted that rational energy education must go beyond attention to "elementary" conservation measures – such as turning off lights – to promote understanding of energy concepts. Miller (2004) reported that a slightly higher proportion of U.S. adults qualify as scientifically literate as compared to adults in Europe and Japan, and he attributed this to the fact that the U.S. is the only major nation that requires general education science courses for liberal arts students. Hobson (2003) suggested that a scientific literacy course for a nontechnical audience should have four elements: a focus on concept rather than calculation, an "interactive, inquiry-oriented" teaching strategy, an inclusion of scientific findings that define a modern scientific world view, and presentation of material that is socially relevant. Zografakis et al. (2008) described a project showing the positive effectiveness of "energy-thrift" education on the conservation behaviors of school children and their parents. Kandpal and Garg (1999) suggested a number of objectives that energy-education programs should address, and Hobson (2003) identified critical energy topics for a physics literacy course.

As part of a comprehensive project to develop, administer, and analyze results from an energy literacy survey, DeWaters et al. (2007) identified an energy literate individual as one who:

- has a basic understanding of how energy is used in everyday life;
- has an understanding of the impact that energy production and consumption have on all spheres of our environment and society;

- is sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources;
- is cognizant of the impact of personal energy-related decisions and actions on the global community; and
- strives to make choices and decisions that reflect these attitudes with respect to energy resource development and energy consumption.

As engineering faculty, the authors believe that a technically literate public is crucial to the development of rational energy policies. With this in mind, a faculty team from the College of Engineering & Science developed a course on energy for nontechnical students. The course has been adopted into the university's core curriculum, satisfying the objective for scientific literacy in natural sciences. It is the first general education offering from engineering faculty. The course has been offered three times to date, the first year to seven students, the second year to a class of 22, and the third time to 30 students which is the maximum capacity of the class. Many majors were represented, including accounting, architecture, mathematics, chemistry, education, biology, business, criminal justice, political science, and history.

The urban area where the campus is located is a region of racial, cultural, and economic diversity, and the student population at the University reflects that diversity. Because the course is included in the University core curriculum, the material is available to the entire student body. If the first two years are any indication, the growth in interest for the course will go a long way towards contributing to increased energy literacy among our graduates.

Additionally, the university has a long tradition of promoting environmental responsibility and the use of sustainable technologies. Teaching about the need for conservation of energy and resources and reduction in pollution and waste promotes the University mission and values and is an important part of student education.

During the course development, a few challenges presented themselves: how to present technical material to a largely nontechnical audience in a way that provides a sound physical understanding, while maintaining interest; how to tailor the material to accommodate a diversity of academic backgrounds, particularly regarding math skills; and how to make the course topics accessible and meaningful.

The paper begins with a discussion of course structure and content, including a description of course projects from the first two offerings. An analysis of results from pre- and post-surveys is then presented, and the article concludes with a summary of lessons learned and a description of planned course improvements.

Course structure and content

The overriding goals were to inform students about energy production and consumption patterns, various technologies and their environmental consequences, and the pros and cons of renewable and nonrenewable energy systems. Other objectives were to provide a straightforward yet sophisticated appreciation of the negative effects of unconsidered energy consumption, a layman's knowledge of the physical laws governing and technologies behind conventional and alternative energy production, and an array of tools to evaluate and implement energy conservation strategies on personal and corporate levels. In line with the desire to make the course as accessible as possible to all university students, the faculty decided that the only prerequisites for the course would be knowledge of basic algebra and simple spreadsheet analysis skills.

The outcomes for the course are shown in Table 1. With these outcomes in mind, a semester outline was developed as shown in Table 2.

Three instructors co-taught the initial offering. The lead instructor was a mechanical engineering faculty member, who covered 50% of the course material. Material on pollution was taught by an environmental engineering faculty member, and nuclear technology along with safety and proliferation issues was taught by a faculty member from physics. Subsequent offerings were co-taught by the mechanical and environmental engineering faculty members. The format is traditional lecture augmented with PowerPoint presentations.

The instructors felt that it was important for the students to have a textbook with regular reading assignments and weekly homework. Numerous textbooks are available for such a course, including *Energy and the Environment: Sources, Technologies, and Impacts*, by Reza Toossi, *Energy: Its Use and the Environment* by Hinrichs and Kleinback, and *Energy and the Environment*, by Ristinen and Kraushaar. The text by Ristinen and Kraushaar was chosen because its contents align most closely with the course objectives, and it contains a good number of both qualitative and quantitative end-of-chapter problems. The lectures followed the general flow of the book but were embellished with many visuals from various sources.

Course Projects

Several projects were developed to give students practice in exercising the principles discussed in class. In the first year's offering, a guest lecturer from University Facilities spoke with the students about the University's conservation efforts. He provided an electrical power versus time curve for the library for a day in February, and the students were assigned the task of determining the energy use for that day. The library was chosen for the project because it had the most reliable and thorough data. Once students determined the electrical energy usage by estimating the area under the power curve (highlighting the connection between power and energy), they calculated the daily electricity cost using the University's purchase rate. In their reports, students discussed why they thought the meter power rose and fell throughout the day, taking into account building occupancy times and various electrical loads. They were also asked to suggest ways that the library could decrease electricity usage.

Another project involved estimation of the library's heat loss for the month of February, given a plot of outside air temperature versus time. Assuming the average inside air temperature was 70°F and with further assumptions about roof and wall construction, students were required to visit the library to a) estimate the total outside wall plus roof area and b) the window glass area and glass construction (single or double pane). Once they determined the total February heat loss, they calculated the associated cost by assuming the energy came from burning natural gas with a conversion efficiency of 80 percent.

In the subsequent offering, a service learning project was incorporated. Service learning is a cornerstone activity in numerous courses, supporting the University's mission to provide excellent student centered education within its urban context. Many city residents are burdened with high energy costs, and are in need of strategies to reduce their natural gas and electricity bills. The students worked in teams to perform energy audits for the residences in the northwest area of the city. The students were trained on how to perform the audits, install energy-saving material, and calculate estimated energy savings. The deliverable was a simple, clearly written audit report to the residents in which conservation measures and potential savings were identified.

Course Term Paper

In addition to the project, students were required to choose an air pollutant and write a term paper discussing three points: the sources of the pollutant, the causes of concern with the pollutant, and the solutions that can be implemented to either reduce its emission or totally remove it. Along with the paper, students prepared a PowerPoint presentation followed by a class discussion. By researching atmospheric pollution and its sources and effects, students gained a deeper appreciation of the impact of energy-related choices, behavioral actions, and human activities, as well as the price of technological advances and modern lifestyles on the environment.

Assessment of Course Outcomes

In order to assess the course, we link the course outcomes listed in Table 3 to the university core curriculum outcomes for physical science. Each of the core outcomes is assessed through specific homework, exam, or project elements. The ways in which each core outcome is covered and assessed are outlined in Table 1. Also included in Table 1 are example student exercises taken from homework, exam, or project assignments. The rubric for assessment of the term project is shown in Table 4, and the rubric for assessment of the term paper is shown in Table 5.

Table 3 also lists two of the outcomes associated with the university's reading, writing, and research across the curriculum (RWR) initiative. All science classes must meet these outcomes in addition to the course outcomes. The term paper assignment serves as the assessment mechanism for the RWR outcomes.

Results and Discussion

Pre and post surveys

The instructors wanted to gauge the effectiveness of the class on the students' energy literacy. In order to also compare our results with those from a wider survey, we chose questions from the NEETF report (NEETF 2002). The NEETF national survey solicited responses from 1,503 adults 18 years of age and older. Survey questions were divided into those addressing knowledge and those addressing attitude and behavior. One danger with using a pre- and post-test with the same survey items is that the classroom presentation may be biased towards specifically addressing the survey questions. The course material was developed before the NEETF survey was chosen as an assessment tool, so this effect is believed to be minimal.

A few of the NEETF survey questions had to be adjusted to reflect trends that are different from those seen ten years ago. For instance, one item concerns the average miles per gallon for U.S. vehicles for the past ten years. In the publication year for the NEETF survey, 2002, the answer was that average MPG had gone down. On the other hand, in 2012, average MPG has increased over the last ten years. Another question dealt with the percentage of oil imported from foreign sources. In 2001, the answer was 55%, while in 2017 the U.S. net imports of petroleum from foreign countries were equal to about 20% of the total consumption, according to the U.S. Energy Information Administration. Furthermore, the question in the NEEFT survey asking how most of our electricity is generated does not include natural gas, which now rivals coal for electricity production. In general, we believe a weakness of the NEETF survey was the inclusion of questions geared towards respondents' knowledge of percentages, which misleadingly tests the respondents' ability to retain data rather than a more qualitative understanding of energy issues.

Before the course, 42% of the 30 responses to the knowledge questions were correct. This percentage is remarkably close to the NEETF result of 41%. After the course, the percentage of correct responses rose to 58%, indicating an appreciable improvement of 38% increase in energy knowledge. Figures 1 through 3 show results for a few select questions indicative of what we believe to accurately judge energy literacy. The NEETF results are also shown. Figure 1 clearly shows that students gave up their misconceptions regarding energy sources for electricity generation, recognizing by the end of the term that most electricity comes from burning oil, coal, and gas. Figure 2 indicates that some students before the course mistakenly believed that most household energy consumption is due to lighting, heating water, or refrigerating food, but by the end the vast majority recognized that heating and cooling comprises our largest energy use. Figure 3 summarizes the percentage of correct responses of the students before and after taking the class. For questions 1 and 2, the percentage of correct responses rose from 53% and 57% respectively to 89%, indicating an improvement of 68% and 56% increase respectively for these questions. Similarly, questions 6 and 8 showed a remarkable increase in percentages of correct answers. Their percentages rose from 13% and 50% to 46% and 89% respectively, indicating an improvement of 254% and 78% increase respectively for these questions. Figure 3 demonstrates that students improved their knowledge on all questions except for two. Question 4 asks which fuel is used to generate the most energy in the U.S. each year. The majority of students picked coal. Question 9 inquires about the percentage of oil the U.S. imports. As the case with every percentage question, students have hard time retaining numerical data and as a result, the majority of the responses were incorrect.

The importance of energy conservation was a constant theme throughout the course, and Figure 4 shows that by the end of the term most students agreed with the scientific community that conservation is the most effective strategy for mitigating our energy problems. Question 7 in the opinion/behavior NEEFT survey asks how often (frequently, sometimes, or never) specific actions are done. These actions represent environmentally conscious behaviors. Summing up all the responses of the 30 students for the 7 actions in question, a total of 78, 93, and 39 were registered for frequently do it, sometimes do it, or never do it, respectively, at the beginning of the course. After taking the class, student responses indicated a total of 84, 83, and 29 for frequently, sometimes, or never doing the actions, respectively.

The NEETF survey also asked how students felt about their own energy knowledge. Before the course, 84 percent of the students felt they only knew "a little" or "a fair amount" about energy issues and problems. At the conclusion of the course, 93 percent indicated they knew "a lot" or "a fair amount." Although subjective, this measure is consistent with the increase in actual knowledge as indicated by results for the knowledge questions.

Conclusion and future improvements

Engineers and scientists like to "do the math." Indeed, backing up assertions with simple calculations can be an effective way to demonstrably reinforce concepts in the area of energy education, as writers such as Tom Murphy (2013) and David MacKay (2008) convincingly show. When the instructors embarked on this course delivery, they had high hopes for being able to clarify for a general audience why having solar-powered cars is not a possibility, or why the efficiency of a coal power plant can never reach 100 percent. Unfortunately, the students in the class were a bit overwhelmed by the calculations involved. Apparently determining the number of Snickers bars that needs to be burned to provide America's electrical needs, or estimating the monthly operating cost for a 100,000 Btu/h natural gas furnace was not the kind of activity they signed up for, especially in a general elective. Midway through the initial offering, the faculty recognized this and adjusted the homework assignments and exams to favor qualitative over quantitative questions. In subsequent offering of the course, the problem was only partly remediated because a service learning project was introduced and involved a large amount of number-crunching in order to provide residents with estimates of energy savings.

Simple calculations can be an effective way to demonstrate energy principles. Furthermore, the ability to recognize physical principles that apply to a given problem, identify governing formulas and desired outputs, perform calculations with numbers and units cancellations, and intelligently judge the results are key abilities for an informed, energy-literate citizenry. Students need to overcome their anxiety with "word" or "story" problems as they face the real world, and the challenge for future deliveries will be to advance students along this path. With this in mind, the hope is to devote more interactive class time to quantitative examples and exercises.

In future offerings, energy literacy will be gauged across more groups in the student body, making comparisons between technical (science and engineering) and nontechnical students, science and engineering students, technical freshmen and technical seniors, and among different nontechnical majors. The energy knowledge survey will be modified to include more questions on environmental topics, reflecting an increased emphasis on pollution and waste disposal. The survey will also be adjusted to reflect present trends and facts. An assessment of course outcomes based on graded materials (exams, homework, project, etc..) will be performed to gauge student understanding and grasping of course content. Even though this is a core course for non-engineers, future assessments will follow an ABET format.

In the future, more material discussing environmental stewardship also will be included. The fact that the United States with five percent of the world's population consumes 25 percent of the world's energy resources brings into light fundamental questions of justice. Our standard of living is tied to the rate at which we use energy resources. The rest of the world aspires to our standard of living. But, in order for the rest of the world to use energy at the rate we do, the resources of five earths would be required - an obvious impossibility. Given that we reject the scenario of maintaining the global status quo, what is our ethical responsibility? Do we sacrifice our standard of living and adopt lifestyles that use less energy? Do we replace current energy resources with ones that are renewable? Is it possible to do so and still consume the same amount of energy? Or do we lead a global effort to develop political, technological, and economic strategies to ensure a more equitable energy distribution? Although these questions have been addressed in a superficial manner, the faculty members would like to devote more time in class exploring these issues, and they plan to invite guest speakers to talk about environmental ethics and social justice.

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Table 1. **Course Outcomes**

a.	**Demonstrate a basic literacy regarding energy conversion and use: forms of energy, physical laws, terminology, and units**
b.	**Describe the origin, consumption patterns, and environmental and societal consequences of fossil fuel use**
c.	**Explain the basic concepts behind combustion and heat engines**
d.	**Describe and analyze technologies for thermal and electrical energy production from solar energy**
e.	**Describe and analyze technologies for wind, geothermal, hydroelectric, and biomass energy conversion**
f.	**Discuss the issues surrounding nuclear energy conversion**
g.	**Analyze energy consumption patterns for residential and industrial sectors, and propose energy conservation measures**
h.	**Discuss the issues surrounding transportation energy use**
i.	**Analyze the sources and effects of air pollution**
j.	**Explain the relationship between global energy use and climate change**
k.	**Evaluate policies for dealing with global energy consumption including international protocols and cap-and-trade strategies**
l.	**Evaluate the potential for renewable and nonrenewable energy sources to meet global demands**

Table 2. **Topical Schedule**

Topic	Description	Duration (weeks)
Introduction	U.S. and worldwide resource production and allocation, summary of technologies	0.5
Fundamentals	Definitions, units, statements of 1^{st} and 2^{nd} Laws of thermodynamics	1.5
Fossil Fuels	Petroleum, natural gas, and coal: formation, global distribution, history of development, production technologies, rates of depletion	2
Heat Engines	1^{st} and 2^{nd} Laws for power and refrigeration cycles, practical operation of gas and steam turbines, internal combustion engines, refrigerators, and heat pumps	1
Solar Energy	Distribution of the solar resource; passive, thermal, and photovoltaic systems; design principles	1
Other Renewable Sources	Characteristics of hydropower, wind power, ocean thermal energy conversion, biomass, geothermal, tidal, and wave energy systems	2
Energy Conservation	Household energy use, heat transfer through building envelopes and insulation	1
Nuclear Energy	Fundamentals of nuclear energy conversion to electricity, safety and environmental issues	2
Energy for Transportation	Vehicular energy conversion fundamentals, gasoline and diesel engines, biofuels and their potential, hybrid and electric vehicles	1
Pollution and Climate Change	Pollutant sources and characteristics, the greenhouse effect, ozone depletion	2

Table 3. Coverage and assessment of core outcomes (associated course outcomes are given in parentheses)

Outcome	Coverage	Assessment mechanism	Example homework, exam, or project statements. Expectations for student solutions.
1: Acquire basic contemporary science literacy that enables discussion of scientific issues at a non-professional level of expertise. (course outcomes a, c, d, e, f, and h)	All material presented in class is related to this outcome. The course objective as stated in the syllabus is "To provide the student with the ability to critically evaluate various technologies used to convert energy for human use from technological, societal, ethical, and economic viewpoints."	Homework and exam problems.	<u>Problem 1 from HW #1:</u> *What are the two major problems created by depending on fossil fuels for most of our energy?* <u>Expectations:</u> Student will explain that the two major problems created are: (1) the fossil fuel resources are limited, and (2) unintended environmental consequences result from the extensive use of the fossil fuels; this leads to atmospheric pollution that causes health problems and possible world climatic change. <u>Problem 4 from Exam #2:</u> *Explain the operational difference between a conventional and high efficiency natural gas furnace.* <u>Expectations:</u> Students will explain that a high efficiency furnace recovers thermal energy from hot combustion gases before discharging them to the atmosphere.
2: Apply the distinctively empirical methodology of the sciences to study physical phenomena. (course outcome g)	Students are given a project to analyze UDM building energy consumption using temperature data and building envelope measurements.	Project.	"Analysis of UDM library electrical and temperature data" problem statement. Expectations are described in the scoring rubric given in Table 2.
3: Recognize the interdisciplinary aspect of science, not only to other forms of scientific inquiry, but to fields of study outside of science. (course outcomes b and k)	Lectures cover the relationship between energy and power, and the economic effects of energy use. A term project involves an economic analysis of UDM library electricity and heating costs. It also addresses how human behavior can influence energy consumption.	Homework and exam problems. Project. "Analysis of UDM library electrical and temperature data"	<u>Problem 1 from HW #4:</u> *You can purchase a 15 watt compact fluorescent lamp for $4 that is rated to last 10,000 hours. This lamp provides the same light output as a 75 watt incandescent lightbulb that costs $0.50 and lasts 1000 hours. Based on an electric energy cost of $0.10/kWh, calculate the money saved over the life of the fluorescent lamp by using it instead of the conventional lightbulb. Include the cost the lightbulbs.* <u>Expectations:</u> Students will determine energy use by multiplying power by time for both bulbs, and perform an economic analysis to determine that the cost savings is $61.
4: Identify ethical boundaries and implications of contemporary scientific developments. (course outcomes i, j and k)	Students are confronted with the consequences of rising energy consumption in lectures and reading assignments. Energy resource depletion and inequitable resource distribution along with effects of pollution are also covered. Nuclear energy promises and perils are described.	Exam problems.	<u>Exam 3 problem:</u> *Briefly describe the pros and cons of nuclear power.* <u>Expectations:</u> Students will identify pros: no greenhouse gases or harmful effluents, breeder reactors promise abundant fuel for centuries. Cons: expensive, radiation risk due to a Loss of Coolant Accident, radiation risks in transportation and storage of spent fuel rods, possibility of nuclear weapon proliferation.
5: Identify the historical development and social impact of science. (course outcomes b and l)	The history of fossil fuel use is covered in lectures and reading assignments. The societal impact of "peak oil" is discussed.	Homework and exam problems.	<u>Problem 1 from HW #3:</u> *Estimate the cumulative production from 1860 to 2003 for natural gas using the area-under-the-curve method (the method we used in class for oil). Use Figure 2.6, which is also reproduced in the PowerPoint lecture Fossil Fuels on the course website. Compare your estimate to the value of 1037 tcf given in the text (see page 47). Using your estimate for cumulative production, what is the ultimate recovery, Q_∞, for natural gas in the U.S.?* <u>Expectations:</u> Students will estimate the area under the

			production rate curve as 1054 tcf , with 1925 tcf for ultimate recovery. Problem 9 from Exam #1: *Explain what the term "peak oil" refers to.* Expectations: Students will sketch a graph showing the "Hubbert curve," demonstrating how oil production rises, peaks, and declines over time. They will state that after the peak, if demand remains the same or rises, prices for oil and other commodities will escalate.
RWR1: Develop a purposeful writing process appropriate to the argumentative and analytic nature of academic work that includes generating ideas, focusing, drafting, and revising—revision being a process that involves reflection, editing, feedback and publishing for a particular audience.	A term paper focusing on a pollutant of the student's choice is assigned in the middle of the term. The paper is reviewed and edited by the faculty and returned to the students for a final revision due near the end of the term. The scoring rubric shown below as Table 3 is used for both the draft and final papers.	Term paper.	Term Paper: For this paper, the student will pick an air pollutant and will discuss how the pollutant ends up in the atmosphere, why it is a concern for humans and/or the environment, what solution(s) was proposed to reduce its emission, transform it into a less dangerous chemical, or totally remove it, and finally what recommendations can be suggested. The paper should be written as a science paper, following the provided format, and including trustworthy and dependable references. A first draft will be due a month after the paper is assigned. The draft will be reviewed by the faculty and comments will be provided. Students will revise and edit the manuscript based on the faculty feedback.
RWR2: Comprehend and practice ethical methods to avoid plagiarism and infringements of copyright regulations.	The faculty will explain to the students what is considered plagiarism when the term paper assignment is given and how to avoid it by paraphrasing ideas/statements and using proper citations.	Term paper.	See above. Expectations: Students will submit the term paper to Blackboard anti-plagiarism software SafeAssign before the final version is handed in at the end of the term. The students have 2 attempts to use SafeAssign and correct any improper citation.

Table 4. Scoring rubric for term project

	4	3	2	1
Calculations for electrical energy	Correct relations are used for determining electrical energy from power data. Numerical calculations, including units conversions, are correct.	Correct relations are used, but units are incorrectly canceled and stated, or there are some arithmetic errors.	Correct relations are identified but applied erroneously, or power data is misinterpreted.	Incorrect relations are used, or there are many errors in application and calculation.
Calculations for heating energy	Correct relations are used for determining heat loss through building envelope. Numerical calculations, including units conversions, are correct.	Correct relations are used, but units are incorrectly canceled and stated, or there are some arithmetic errors. There may be errors in building envelope measurements.	Correct relations are identified but applied erroneously, or temperature data is misinterpreted. There may be significant errors in building envelope measurements.	Incorrect relations are used, or there are many errors in application and calculation.
Discussion	Suggested ways for the library to decrease electricity usage are well reasoned. Discussion of the accuracy of the heating estimate clearly relates to the assumptions. Discussion is well articulated.	Suggested ways are limited in number or dubiously reasoned. Accuracy of the heating estimate is only partially related to the assumptions. Discussion may lack clarity.	Only one of the two discussion items (ways to decrease electrical usage and accuracy of the heating estimates) is addressed adequately, or there are significant errors in reasoning.	Discussion is nonexistent, or thoroughly irrelevant, or nearly impossible to understand.

Table 5. Scoring rubric for term paper

	3	2	1
Paper statement	The paper statement is clearly articulated.	The paper statement is somewhat ambiguous or scientifically questionable.	There is no clear paper statement.
Organization	The paper follows the standard format for a science paper. All sections are present. Evidence in support of the paper statement is ample and appropriate. The argument supporting the statement is logical and clear. The conclusion is succinct and consistent with prior statements.	The paper follows the standard format for a science paper. All sections are present. Supporting evidence is included, but somewhat limited in amount or with questionable relevance; or the argument can be followed, but some ambiguity is present.	The paper does not follow the standard format for a science paper. Not all sections are present. There is little evidence of a coherent organizational plan. Very limited literature search.
Revising and Editing	The author revised and edited the paper according to the faculty feedback from the first draft.	The author partially revised and edited the paper according to the faculty feedback from the first draft.	The author did not take into consideration the faculty feedback and did not revise or edit the first draft.
Grammar and Spelling	The grammar is nearly perfect. No spelling errors.	Some grammatical mistakes detract from the paper's readability. No spelling errors.	Grammatical errors are numerous. Many spelling errors.
Attributions	Reference to other sources is given as appropriate and citations are properly formatted.	The originality of some material is questionable. There are some errors in citation formatting.	Some material is clearly plagiarized. Citations are nonexistent.
Format	The paper follows the format provided under General Considerations.	The paper mostly follows the format provided under General Considerations.	The paper does not follow the format provided under General Considerations.

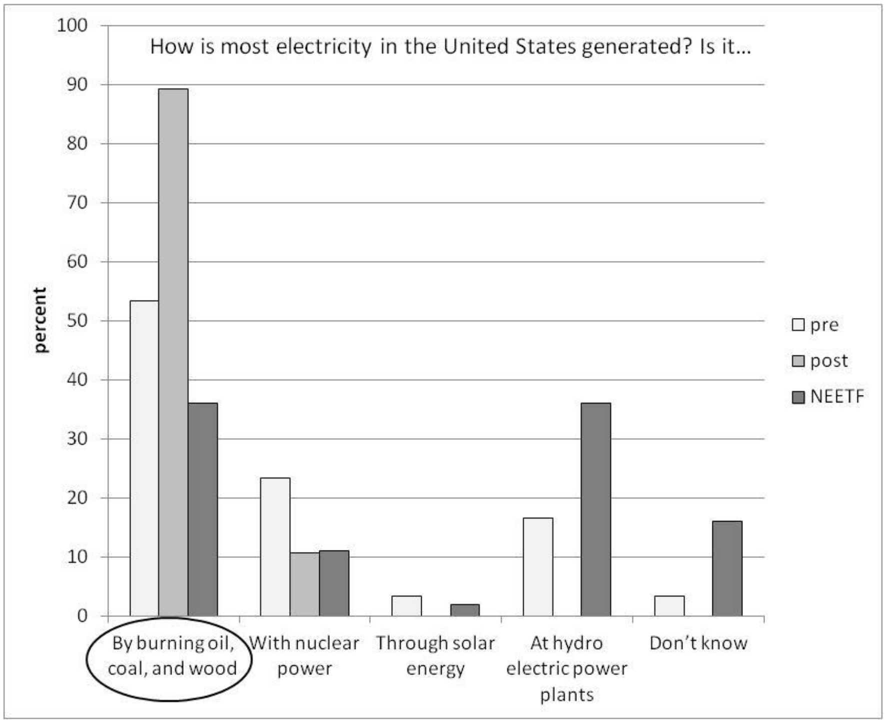

Figure 1. Student response to energy source for electricity generation

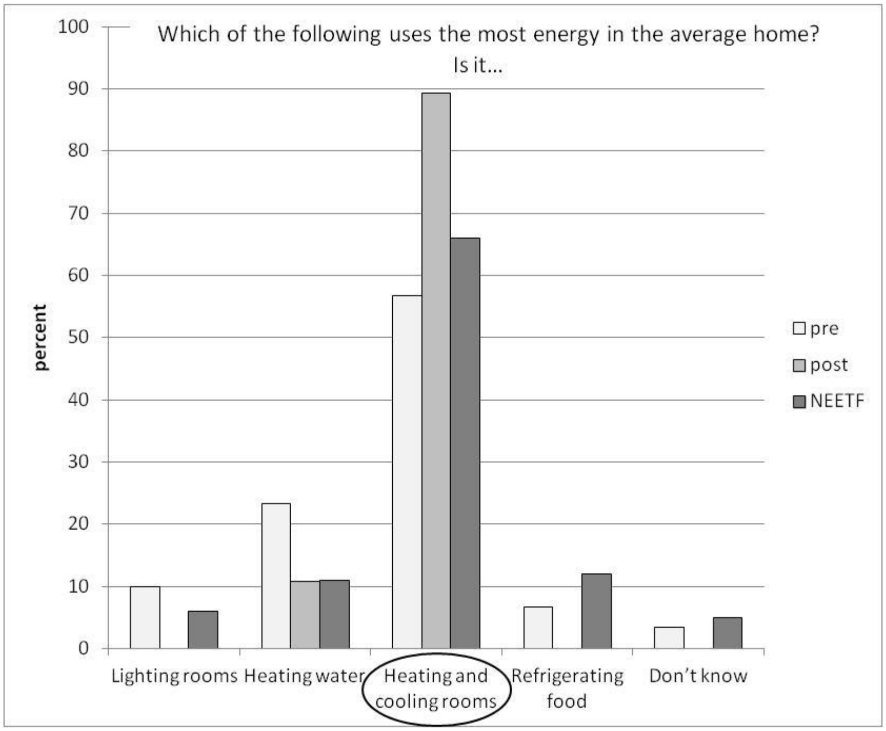

Figure 2. Student response for household energy use

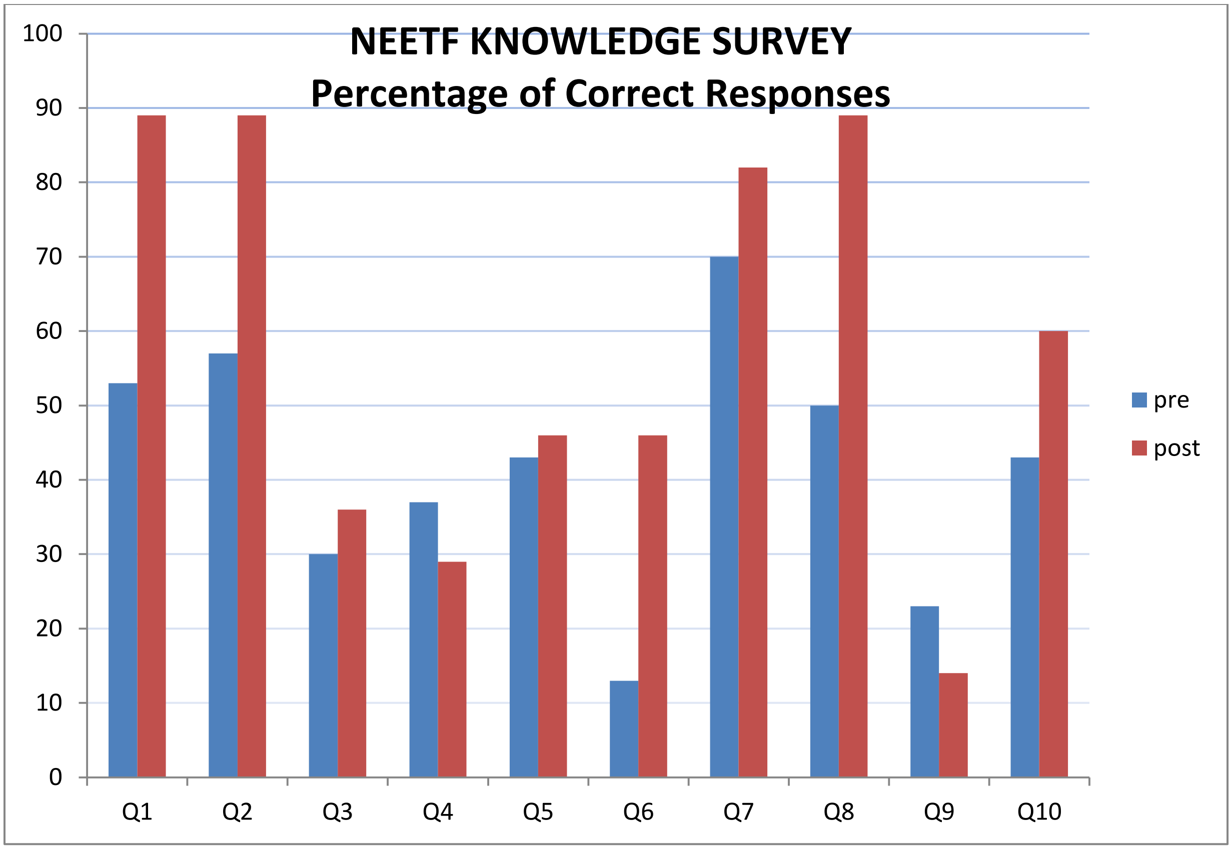

Figure 3. Student pre and post correct percentages to the 10 questions of the NEETF knowledge section

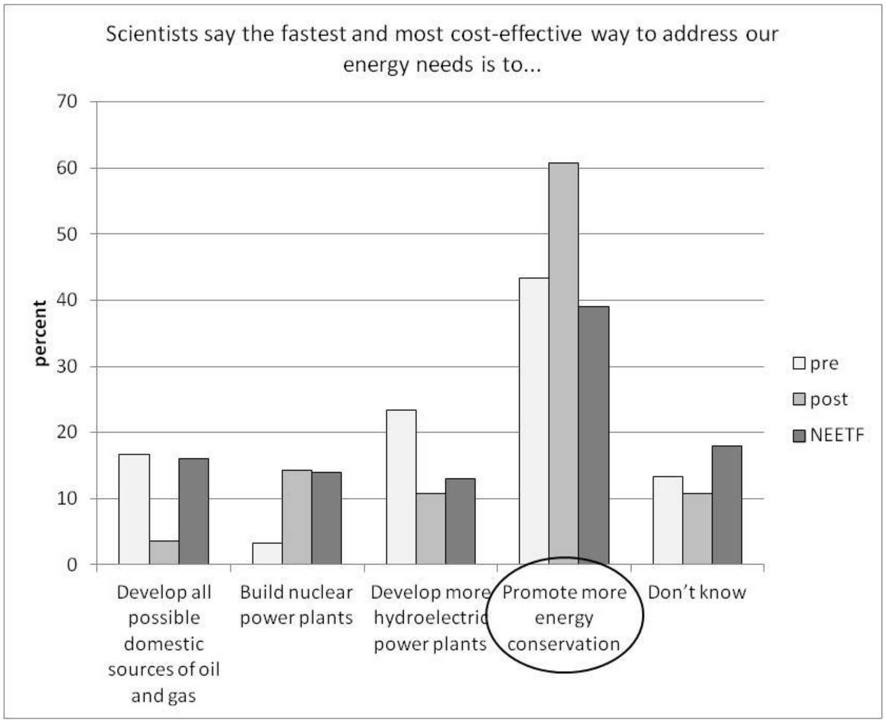

Figure 4. Student response regarding ways to address energy needs

Modified NEETF Survey

Knowledge questions

1. How is most electricity in the United States generated? Is it…
    a. By burning oil, coal, and wood
    b. With nuclear power
    c. Through solar energy, or
    d. At hydro electric power plants?
    Don't know

2. Which of the following uses the most energy in the average home? Is it…
    a. Lighting rooms
    b. Heating water
    c. Heating and cooling rooms, or
    d. Refrigerating food?
    Don't know

3. Which of the following sectors of the U.S. economy consumes the greatest percentage of the nation's petroleum? Is it…
    a. The residential sector
    b. The commercial sector
    c. The transportation sector, or
    d. The industrial sector?
    Don't know

4. Which fuel is used to generate the most energy in the U.S. each year? Is it. . .
    a. Petroleum
    b. Coal
    c. Natural gas, or
    d. Nuclear?
    Don't know

5. Though the U. S has only five percent of the world's population, what percentage of the world's energy does it consume? Is it…
    a. 5 percent
    b. 15 percent
    c. 20 percent, or
    d. 25 percent?
    Don't know

6. In the last ten years, which of the following industries in the U.S. economy has increased its energy demands the most? Is it…
    a. The food industry
    b. The transportation industry
    c. The computer and technology industry, or
    d. The health care industry?
    Don't know

7. In the past ten years, has the average miles per gallon of gasoline used by vehicles in the U.S. …

a. Increased
b. Remained the same
c. Gone down, or
d. Not been tracked?
Don't know

8. Scientists have not determined the best solution for disposing of nuclear waste. In the U.S., what do we do with it now? Do we…
   a. Use it as nuclear fuel
   b. Sell it to other countries
   c. Dispose of it in landfills, or
   d. Store and monitor the waste?
   Don't know

9. The U.S. currently uses oil from both domestic and foreign sources. What percentage of the oil is imported? Is it…
   a. 10 percent
   b. 20 percent
   c. 50 percent, or
   d. 70 percent?
   Don't know

10. Scientists say the fastest and most cost-effective way to address our energy needs is to...
   a. Develop all possible domestic sources of oil and gas
   b. Build nuclear power plants
   c. Develop more hydroelectric power plants, or
   d. Promote more energy conservation?
   Don't know

Opinion/behavior questions

1. Most of the time, do you think energy conservation and economic development can go hand in hand, or that we must choose between energy conservation and economic development?
   - ❑ Can go hand in hand
   - ❑ Must choose between energy conservation and development
   - ❑ It depends (vol.)
   - ❑ Don't know

2. When it is impossible to find a reasonable compromise between economic development and energy conservation, which do you usually believe is more important: economic development or energy conservation?
   - ❑ Economic development
   - ❑ Energy conservation
   - ❑ It depends
   - ❑ Don't know

3. There are differing opinions about how far we've gone with environmental protection laws and regulations. At the present time, do you think environmental protection laws

and regulations have gone too far, or not far enough, or have struck about the right balance?

- ❑ Gone too far
- ❑ Not far enough
- ❑ Struck about right balance
- ❑ Don’t know

4. Thinking now about some specific environmental and energy issues, at the present time, do you think laws and regulations for the following items have gone too far, not far enough, or have struck about the right balance?

	Gone too far	Not far enough	Struck about right balance
a. Fighting air pollution	❑	❑	❑
b. Conserving energy resources	❑	❑	❑
c. Protecting endangered species of plants, animals, and insects	❑	❑	❑
d. Protecting wetland areas	❑	❑	❑
e. Fighting water pollution	❑	❑	❑

5. Please indicate for each of the following statements about energy whether you strongly agree, mostly agree, mostly disagree, or strongly disagree.

	strongly agree	mostly agree	mostly disagree	strongly disagree
a. Technology will find a way of solving energy problems	❑	❑	❑	❑
b. Energy conservation will play an increasingly important role in the nation’s economic future	❑	❑	❑	❑
c. Private companies need to place more emphasis on educating the public to help solve energy problems	❑	❑	❑	❑
d. Government agencies need to place more emphasis on educating the public to help solve energy problems	❑	❑	❑	❑
e. Energy conservation should be taught in our schools	❑	❑	❑	❑

6. In general, how much do you feel you yourself know about energy issues and problems — would you say you know a lot, a fair amount, only a little, or practically nothing?

- ❑ A lot
- ❑ A fair amount
- ❑ Only a little
- ❑ Practically nothing

❑ Don’t know

7. For each of the following things, please indicate whether you frequently do it, sometimes do it, or never do it.

	frequently do it	sometimes do it	never do it
a. Recycle things such as newspapers, cans, and glass	❑	❑	❑
b. Turn off lights and electrical appliances when not in use	❑	❑	❑
c. Use other types of transportation, such as biking or the bus, instead of driving your car	❑	❑	❑
d. Purchase lamps and appliances that are energy efficient	❑	❑	❑
e. Reduce the use of air conditioning in the summer to conserve energy	❑	❑	❑
f. Lower the thermostat in the winter to conserve energy	❑	❑	❑
g. Accelerate slowly to conserve gasoline when driving	❑	❑	❑

8. For each of the following activities, please check the box if you have done the activity in the past 12 months.

a. Fishing	❑
b. Outdoor swimming	❑
c. Hunting	❑
d. Motor boating	❑
e. Downhill skiing	❑
f. Golfing	❑
g. Bird-watching	❑
h. Gardening	❑
i. Running or jogging	❑

9. Which of the following age categories includes your age?
❑ 65 or older
❑ 55 to 64
❑ 45 to 54
❑ 35 to 44
❑ 25 to 34
❑ 18 to 24