Developing an Energy Literacy Curriculum at Baylor University

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Abstract

As part of the Southern Association of Colleges and Schools (SACS) accreditation effort at Baylor University this past year, the authors proposed a unique course whose purpose was to address the lack of energy awareness on the part of students in general. Furthermore, it was apparent that Baylor University's engineering students, while studying the technical engineering topics in the curriculum, were also unaware of the challenges ahead in the area of energy. This paper examines the development of an "energy literacy" class designed for incoming freshmen in all disciplines. Many students do not know their major as incoming freshmen but they may have an interest in the area of energy regardless of major. As part of the Quality Enhancement Program (QEP), a requirement of SACS, Baylor University was tasked to develop living and learning communities for incoming freshmen that revolved around a theme. The topic of Energy and Society was submitted by the authors and eventually selected for development into a course that was offered for the first time this past fall. Twenty seven freshmen from a wide diversity of disciplines voluntarily signed up for the proposed course. The course meets one semester hour for four semesters. Students who attend the entire course, four semesters, are able to substitute this course for one in their major (agreed upon by the respective curriculum committees prior to the course offering). The first semester is an introduction to energy concepts such as work, power and conservation of energy. The second semester deals with energy production (conventional and alternative/renewable) and usage in society. The third semester looks at the social, political, environmental, and economic impact of energy. The last semester is dedicated to a research project of the students' choice.

Background

In September of 2001, Baylor University's Board of Regents adopted a ten-year plan known as Vision 2012. This plan encompasses a series of 12 imperatives which will lead Baylor University "…to new facilities and to new academic and scholarly environments, approaches and opportunities[1]." Vision 2012 is an ambitious program; however, the results, if achieved, would elevate Baylor to top tier ranks while maintaining its heritage and Christian mission. Particularly important to this project is Imperative I, which seeks to establish an environment where learning can flourish. A 2003 a survey of Baylor freshmen, a part of the National Survey of Student Engagement (NSSE), showed that Baylor students scored below the fortieth percentile on" Active and Collaborative Learning" and "Faculty-Student Interaction.[2]" In 2006, the NSSE showed similar

trends. These findings were deemed unacceptable. Baylor has a rich history of teaching excellence and, as a whole, is very student-centered. As a result of these findings a number of initiatives were begun. One of the most significant changes is the creation of residential learning communities.

One such community, the *Engaged Learning Group* (ELG), is the novel result of a process tied to Baylor's re-accreditation under the Southern Association of Colleges and Schools (SACS). The present accreditation guidelines require every SACS school to submit a Quality Enhancement Plan (QEP). Baylor's plan consists of two components, the ELG structure, aimed at freshman and sophomores, and the Undergraduate Research and Scholarly Achievement concept aimed primarily at juniors and seniors. The principles for each part of the QEP are given below[2]:

1. Engaged Learning Groups are designed to give undergraduate cohorts more opportunities during their first two years to make connections: between subject mater and potential personal vocations: among various disciplines; and between learning and original research (both students' own, and their professors').
2. Undergraduate Research and Scholarly Achievements (URSA), a range of initiatives that leverage the strength of faculty scholarship, complement the Engaged Learning Groups, and promote the integration of undergraduate research and teaching.

A committee of 18 members from across the campus began planning the QEP in 2005. Their work led to an approval of the QEP ELG concept by the administration during the summer of 2006. In September of 2007 the QEP was announced to the campus and proposals were invited. Proposals were submitted in December of 2006. Three ELGs were approved in January 2007. After much refinement, the chosen ELGs were made available to the incoming freshmen through mailings and presentations made during the summer 2007 orientations.

The Energy and Society Engaged Learning Group

The three new ELG's commenced in fall 2007. In each, the students initially begin as freshmen and take one semester hour per semester for four semesters. If students complete the required number of semesters, they will receive credit for a course in their major (typically a laboratory science, in the case of the "Energy ELG.") The four semesters for the Energy ELG roughly adhere to the following topics:

Energy Literacy – This first semester (already completed) connected energy production and consumption with societal and environmental effects. As a foundation, students learned basic unit conversions, calculations for energy values, and the concepts of energy conservation (i.e. the first law of thermodynamics) and efficiency. This seminar also addressed the topics for transition from high school to college. Students wrote a report about some aspect of energy usage, production, etc. that interested them.

Energy Production – This semester (currently in progress) will expose students to energy conversion from fossil fuel, nuclear, solar, thermal, photovoltaic, fuel cell, hydro, alternative fuel, and wind sources. Students will explore how energy is used in sectors such as transportation, housing/HVAC, electronics, agriculture, and industry. Students will also write and research an energy-related scientific hypothesis, e.g. fuel derived from a given source

will create net-positive revenue after X years and Y dollars invested; building Z will reduce its electrical consumption by so much if the following phantom loads are controlled, etc.

Energy and Society – In this semester, stewardship and worldview will be the thread that is woven throughout the topics concerning energy, environment and society. This leads to questions concerning energy production and usage, in particular, which energy sources are appropriate for the future. Energy and the environment, politics, economics, and culture will be addressed. The concepts of sustainable and renewable energy will be explored. Teams of students will write formal research proposals based on promising hypotheses from the previous semester

Energy Research – This seminar allows the student research teams to investigate a thesis/hypothesis that was developed throughout the previous three seminars. The desire for these seminars is to examine the Baylor University campus as an energy laboratory. They will research topics that could be of significant impact to energy consumption/production and energy economics on campus.

The purpose of the proposed Energy ELG is to give Baylor students a foundation upon which to build an informed understanding of complex energy issues. With understanding comes the ability to begin answering the questions confronting society. Specifically, the four overarching learning objectives are:

1.) To develop scientific energy literacy;
2.) To closely examine the production and consumption of energy in both developed and developing countries;
3.) To examine the social, political, environmental and ethical problems of an energy-dependent civilization.
4.) Understand, hypothesize, propose and execute a research project in the theme, "The campus as an energy-efficiency and alternative-energy laboratory."

The burgeoning term "energy literacy" suggests that people exhibit varying degrees of energy knowledge. Many may not fully understand the differences between a BTU and a Calorie, a Watt and a VA, what a KWh is on their electric bill, why there are different grades of gasoline (and what "octane" means), and the foundational place in industrialized civilization of the heat engine. Thus, the central – but not sole – aim of the Energy ELG is to teach the science of energy and therefore to promote energy literacy. The majority of the class time will be spent on objectives 1 and 2, encompassing the science of energy. However, it is objective 3 that makes the science relevant and interesting, and gives it context.

The 4th overarching learning objective concerns undergraduate research. The research theme will be woven throughout the ELG. Its four components – understand, hypothesize, propose and execute – correspond to the four ELG semesters. At the end of first semester, students wrote paper on an energy-themed topic related to the Baylor University Campus, doing "paper" research to back it up. At the end of the second semester, they will defend a hypothesis relating their theme topic to some aspect of energy usage, production, public education, etc., at Baylor. Concluding the third semester, teams will form to write formal proposals to investigate the most viable hypotheses. A $10,000

budget (total) has been set aside to seed the team projects, with the proposed research occurring in the fourth semester. During all phases the student performance will be assessed.

The research theme will support an exciting and independent extracurricular activity. Students will be able to work on topics of their choosing with any professor on campus, with theme writing, proposal writing, speaking and presenting, and independent research all tied together. Topics will vary widely, but example subject areas might be:

- Feasibility of converting campus waste streams into biodiesel, ethanol or methane
- Design of active daylighting systems for campus building
- Passive and active solar designs for new academic buildings
- Energy usage behavior modification studies
- Surveys to estimate student energy literacy
- Cost/benefit business analysis for using alternative energy on campus
- Energy audits for campus sectors such as dormitories, athletic facilities or computing equipment
- Development of curriculum to educate local stakeholders about insulation
- Estimating economic consequences of providing campus hot water via renewable resources

Students will be quite creative here. These activities not only reinforce student learning, but may also provide a relevant and useful product that could result in reducing campus energy usage, fulfill a useful and needed public service and provide experience with which students can assess and direct their own energy resource decisions in the future.

ELG Outcomes and Assessment

The ELG concept is novel and holds great promise for helping freshman adjust to life at college, engaging the faculty on a deeper level, sustaining faculty relationships for a lengthy period, and developing a sense of community and belonging. However, ultimately it is desired to know whether the Energy ELG promotes sound learning about energy. Some evaluation will be conducted by the university ELG oversight team. These assessments are briefly summarized in Table 2 to give a complete picture of the evaluations.

In addition to the engagement and participation assessment, a series of assessment outcome are part of the proposed project. An outline of the proposed outcomes and assessment methods follows.

Outcome 1: Students will exhibit increased energy literacy
Specifically, students will

- Understand the science behind the principal kinds of energy that drive modern civilizations, e.g. fuels, electricity, heat, wind and solar;
- Be capable of manipulating the basic mathematical expressions that model these energy sources;
- Be capable of manipulating and converting between the numerous units for energy, work and power. Develop a feel for the magnitude of each unit system.

Assessment instruments will be somewhat traditional, consisting of one exam and one comprehensive final per semester and a weekly short quiz. Brief quizzes will be administered at the beginning of class using a wireless CPS (Classroom Performance System). CPS units permit students to key multiple-choice responses into their personal CPS transmitter, and to view the aggregate responses instantaneously on a projector. Exams will involve handwritten responses.

TABLE 2: Engagement and Participation Assessment

Goal	Measurement Tool	Implementation	Success if…	Evaluated by
Increase student-faculty interaction	NSSE	Administered nationally even numbered years to 1st and 4th – year students	ELG participants report levels of engagement 5% higher than control group.	NSSE administrator; ELG oversight team
Increase participa-tion in active and collaborative learn-ing	CLASSE*	Administered at end of each semester in selected courses	ELG participants report statistically significant increases in faculty interaction, student-peer collaboration, compared to control group	Baylor University Institutional Research and Testing
Encourage participation in undergraduate research	ELG Internal Study	Focus groups at end of each year	ELG participants will engage in research activities at a rate 25% higher than control group by graduation	ELG oversight team PI and co-PI
Increase retention through first three semesters	ELG Internal Study	Data collected from registration system	Students retain at a rate 5% higher than control group	Institutional Research and Testing

*CLASSE is the Classroom Survey of Student Engagement

During the design of multiple-choice CPS quizzes, each answer option will be given a "literacy rating" between 0 and 100. Similarly, during grading of written examinations, we will assign each written answer a literacy rating from 0 to 100. The energy literacy rating process divorces our assessment of a student's comprehension from that student's execution of the problem solution technique. It also recognizes that comprehension may vary along a spectrum between correct and incorrect. It is, for example, better to claim that, "The U.S. consumes 100 billion kWh of electricity per year," than it is to claim "1.1 trillion kW per year". Though both answers are incorrect, kW/year

is not a valid power metric and should be considered a "low literacy" answer. We will develop and publish specific rubrics for assigning energy literacy metrics. (1.1 trillion kWh per year was the figure in 2001.)

It is also planned to use an assessment instrument developed by the National Energy Education and Training Foundation (NEETF)[3]. On the subject of "Energy IQ," it asks 10 simple questions, and shows that only 12% of Americans can answer seven or more correctly. NEETF questions will be included in the assessment.

The combined assessment will be administered to a control group for comparative evaluation. Baylor's office of Institutional Research and Testing (IRT) works with faculty to identify suitable control populations, controlling for factors such as GPA, SAT scores, distribution of majors, etc.

Outcome 2: Students will understand the principal ways in which energy is produced and consumed

To support this outcome, approximately 1/3 of the classroom lecture time, small group discussion and assignments will focus on

- Energy production technologies, including coal, nuclear, hydro and wind generation, fossil and alternative fuels, and advanced topics like photovoltaics and geothermal technologies;
- Energy consumption, including HVAC and buildings, transportation, real and phantom electrical loads, manufacturing, and agriculture.

The majority of field trips (two per semester, one required for each student) will also focus on energy production. To assess this outcome, we will use occasional examination or quiz questions, but we will rely most heavily on writing assignments. The syllabus calls for at least one short paper on some aspect of energy production or consumption every semester.

It is proposed to use "extrinsic information" criterion as our measurement tool. Extrinsic information consists of inferences, observations, or arguments citing knowledge that does not come directly from class lectures and homework. Such knowledge will instead come from group discussion, readings, student research, field trips, extracurricular film screenings, laboratory exercises and other ELG activities. In a manner similar to the energy literacy rating, it will be assigned to each writing project an extrinsic information score between 0 and 100. The score will take into account factors such as: Did the student synthesize information learned in class to arrive at a reasoned inference that was not given in class? Did the student use information or observations from field trips, laboratories or other extra-curricular activities to support a conclusion? Does the student show evidence of learning from non-assigned readings and their own independent research? Because inquiry-discovery (research) threads are woven throughout the course, and because of the novelty of promoting undergraduate research for so many young students for such a long duration (two years), we expect there will be much room for improvement in the extrinsic information metrics as we learn how to better organize and facilitate this aspect of the ELG.

Outcome 3: Students will understand some of the social, political, environmental and ethical problems associated with modern energy-dependent societies

Leveraging the two previous outcomes (energy literacy and extrinsic information), students will be prepared to articulate and defend an informed position related to the social dimensions of the production and consumption of energy. Students will be able to examine the sustainability of a given

energy-related decision or event, estimate its environmental and economic consequences, and participate knowledgeably in America's political process when it relates to the subject of energy. They will be prepared to digest and understand what they see or read about energy in the media, and make informed and beneficial decisions about energy in their own lives. It is proposed to use "value-added assessment" as the principal method to asses whether students are advancing in their understanding of these non-technical issues. Value-added quizzes will utilize the CPS. While some questions will be designed to measure energy literacy, some will be designed to gauge how informed students are about social energy issues. We will design questions of this nature and issue them at the beginning and end of each semester, and at the beginning and end of two-year ELG cycle. Questions may be, for example, "Is the claim that drilling in the Artic National Wildlife Refuge will stabilize US gasoline prices (highly likely) (somewhat likely) (unlikely) or (I don't know)?" After an examination of the magnitude of US oil consumption, the economics of oil markets and the nature of giant and super-giant oil field production curves, answers should migrate toward a reasoned peak, "unlikely."

Outcome 4: Students will understand and practice the scientific method through experience with a research project

To reiterate, in each of the four semesters, respectively, students will: research and write about an interesting topic within the broad research theme; develop a hypothesis that links two or more variables in their topic; propose a research plan (including a small budget) to examine the hypothesis; and execute the research plan under faculty guidance. The theme will be "The campus as an energy-efficiency and alternative energy laboratory."

There are three principal mechanisms to assess progress.

- Written deliverables, described in the preceding paragraph;
- Final oral report at end of 4th semester;
- Survey of faculty research advisors.

Assessment will be designed to illuminate four corresponding questions: can the students understand a problem (develop a well-formed inquiry), hypothesize an answer or outcome, prepare a plan to discover that answer or outcome, and execute the plan? It is difficult to quantify how well students have learned the inquiry-discovery process because sometimes research fails or produces mundane results. However, that does not imply the student has failed. Therefore, we will score this outcome on a somewhat courser scale of 1 (poor) to 5 (excellent) assigning a score to each of the four areas – inquiry, hypothesis, planning, execution. Scores will be aggregated from each student's written deliverables, plus the oral report at the conclusion of the project, and a survey of the faculty mentor's perception about each of these four areas. (Faculty research mentors will guide the students through the execution part of the student research, though they may also be involved in the other three areas as well. Faculty mentors may be any qualified and willing faculty member on campus.)

Table 3 summarizes our proposed learning outcome assessment methodology.

TABLE 3: Learning Outcomes Assessment

Goal	Measurement Tool	Implementation
Increased energy literacy	Literacy score (0 to 100), NEETF "Energy IQ" test	CPS quizzes, written examinations
Understand how energy is produced and consumed	Extrinsic information score (0 to 100)	Short papers, middle of each semester
Articulate social connections to energy	Discussion, value-added assessment	Small-group discussions, CPS quizzes
Students understand and practice scientific method	Asses inquiry, hypothesis, plan, execution (1 to 5)	Major written assignments end of semester, faculty mentor survey

Conclusions and Long Term Goals

Thus far, only one of the four ELG semesters has been completed and the data for this semester has not been compiled. Overall, the first semester was a success according to student comments. Since this was the first offering of the ELG, much was learned and much is still to be learned concerning the administration of such a course. The course is seen as a very positive step in beginning to address the problem of Energy Literacy. The Energy ELG took 27 incoming freshman from across the campus, housed them together, sponsored co- and extracurricular activities built community and engagement with faculty, and will keep the group (faculty and students) together for 2 years while studying an interdisciplinary academic subject. Students will study energy, how it is produced and used, and its societal impact. A full spectrum of academic and social activities will transpire, culminating with 4th semester sponsored research projects within the ELG theme, "The campus as an energy-efficiency and alternative-energy laboratory."

The project will also support a rigorous and in-depth assessment of four specified learning outcomes related to energy and to student aptitude with the inquiry-discovery process. Opportunity exists to improve, as the first offering of the Energy ELG will conclude in spring 2009. ELG teams that show good assessment efforts will be encouraged to restart their ELG, which is the intention of the authors. The second ELG will conclude in spring 2011, giving a complete and thorough assessment-improvement picture. If successful, this novel learning structure will be adaptable to almost any residential campus.

In the long run, energy and sustainability are bound only to increase in importance. Many researchers and authors feel that world energy usage is not only unsustainable, but that industrial economies will experience continuing volatility as non-renewable resources dwindle. Solutions must come not only from technical innovation, but also through changes in business practices, legislation, and personal choices. Individuals in all walks of life will be affected by the changing world energy situation. This project has the potential to elevate students' comprehension of the complete energy picture, and to give them tools that will remain relevant and useful throughout their lives and careers.

References

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