SESSION 4: Pedagogy and Assessment of Student Learning

Chaired by **David Gosselin**, Ph.D., Director of Environmental Studies at the University of Nebraska-Lincoln and **Jan DeWaters**, Ph.D., Assistant Professor, Walter H. Coulter School of Engineering at Clarkson University

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Beyond Geopolitics: A Pedagogy for International Energy Policy

Keywords: Energy and society, international relations, pedagogy

Abstract

Energy challenges are not only technical but are also societal. Additionally, many energy policy issues are not bounded by nation-states but are transnational or even global in nature. Yet students in the social sciences, including in international relations, often lack formal education in how energy systems work from a comprehensive technical, social, and policy perspective. Many energy courses offered in international relations departments focus primarily on oil geopolitics, which is a crucial issue but an incomplete depiction of the relevance of energy systems both to the field of international relations and to social science students interested in careers related to energy policy. This presentation will discuss the approach taken in a new course on international energy policy being taught in the international relations track at James Madison College, a public affairs and public policy liberal arts college within Michigan State University. This course offers a comprehensive overview of international energy policy, its challenges, and its opportunities. It examines energy from a social science and humanities perspective, while also focusing on fostering basic technical literacy in how energy systems work.

The first section of the course provides an overview of how energy systems work. It encourages students to think of energy as an intertwined social and technical challenge, rather than simply a technical challenge. Then students are introduced to several major theoretical concepts in energy systems analysis, to provide tools in their toolkit for analyzing energy. These concepts include energy security, geopolitics, energy governance, and energy justice. The second section of the course focuses on fossil fuels and their extensive implications. It addresses the driving forces behind global oil prices, the effects of energy subsidies on energy markets, and new methods of fossil fuel extraction include hydraulic fracturing and deepwater drilling. This second section concludes by analyzing country case studies on Russia's natural gas supply and China's increasing demand for fossil fuels. The third part of the course examines electricity generating technologies, including coal-fired power plants and their implications for climate change and development, nuclear power and international proliferation issues, dams and development, and renewable energy transitions. Once students understand how energy systems work and have learned analytical frameworks for assessing them from a sociotechnical point of view, we

conclude by exploring how energy systems can be made more sustainable across the triple bottom line. Given the broad scope of the course, the pedagogy discussed in this presentation would be applicable to those teaching courses on energy policy and energy in society, not just to International Relations courses.

Classroom time includes news article presentations, lecture, and discussion and debate on key themes from the assigned reading. The course also utilizes a variety of hands-on activities. First, there is a group activity in which the students are asked to change the US electricity mix and transportation fuel mix to their liking and then to think through the domestic and foreign policy tools they would use to achieve these changes. Second, students play an 'energy around the world' game that explores who benefits and loses from energy innovation, particularly in the Global South. Third, students play the board game Power Grid, in which they learn about electricity and fuel markets through buying and selling fuels and power plants. Finally, the students simulate a stakeholder debate on the international regulation of the nuclear fuel cycle. The course aims to develop students' ability to apply academic knowledge to real-world energy policy debates. Therefore, the course assignments are designed not just to test understanding of the material but also to assess students' ability to communicate their knowledge to different audiences. In class, students are provided with guidance on writing blogs, op-eds, policy memos, and even Tweets and are then asked to utilize these modes of communication in assignments. For example, one assignment asks students to write a 140-character Tweet in response to the question "why should people care about energy poverty?" and then to write a reflection on the merits and drawbacks of using Twitter as a method for communicating complex ideas. Students then write a 3,000-word final paper on an energy technology or energy challenge either in the format of a policy paper or a scholarly paper.

The course instructor and presenter is an Assistant Professor of International Energy Policy at Michigan State University. She was recently hired in a unique joint appointment between James Madison College and the Michigan State University College of Engineering. At James Madison, she works to increase social science students' engagement at the nexus of technology and society, impressing upon them that understanding technical domains will be important to their public policy careers. In the College of Engineering, she brings a social science and international perspective to technical research underway on energy. In addition to the courses described above, she also teaches a senior seminar on regional and transnational energy systems at James Madison College and co-teaches an interdisciplinary Nuclear Energy and Policy class in the College of Engineering.

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Renewable Energy: An Undergraduate Course

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Abstract

This talk will describe a new intermediate course given in the Environmental Studies Program at The New School. It has been taught twice, and incorporates research activities by the class as a whole, in the process of which the class learns a great deal about the science and technology of non-fossil fuels, their promises and difficulties. Since ameliorating human influenced global climate change is crucial, educating and training students in the skills necessary to accomplish the necessary transition is essential. The course embodies a class project on which everyone works, entitled "Fueling America," whose purpose is to determine what technologies deployed in what manner and in what quantities can eliminate the use of fossil fuels in the United States by a date certain. Knowing that it was impossible, we nevertheless chose an early date, 2030, so that it seemed reachable for the students. The project results in a technical paper, which includes an economic analysis as well as a spatial one. In addition to alternative energy technologies, the technologies and strategies of energy efficiencies were included. Student response has been very positive, with one very good student exclaiming that she learned how hard it was going to be to wean American off of fossil fuels. "I thought it was easy to just use solar," she said. "Not now!" The course began with an overview of the technologies that might be involved, as well as some basic energy concepts, such as the Carnot cycle, conservation of energy, and conversions from one form of energy to another. Although this was an intermediate course, a review of these concepts was necessary and important.

After a few weeks of this, the students felt ready to tackle the main part of the course, the "Fueling America" project mentioned above. Each student was assigned, or volunteered for, a particular energy technology, such as solar, wind, biomass, and so forth, including nuclear. They then did research on their particular technology, and reported back each week as to their progress. Not only specific energy technologies were considered, but also various ways of increasing efficiencies. One student, an Urban Studies major, even went so far as to propose changing suburbs into denser urban areas, to eliminate automobiles and enhancing public transportation.

The end result of the course was the preparation of a fully researched and cited technical report, which was then presented to an audience of faculty and students. Questioning of the students was rigorous, as the audience expected a great deal. In general, the students did very well, although the questioning led them to realize they should go back and do some of the work a little more completely. This "peer review" process was an important part of the learning experience.
The rules of the project were simple. First, they had to use readily available technologies, that could be purchased and implemented now. Second, they had to use the real cost of these technologies, including costs for maintenance, repair, and transportation of equipment to the site. Third, they had to calculate the land mass that would be required; in the case of solar, for example, rooftop availability had to be included in their calculations, if they were planning to put solar panels there. The cost of transmitting the energy to the place of use, together with the land mass required for such transmission, was also required to be part of their calculations.

In pre and post testing of basic energy concepts, the students showed much improvement, though not dramatically more than one would expect from a more traditional course. Student enthusiasm for the course was very high; several of them said that it was the best course they had ever taken. Student enthusiasm for the course was related to the following attributes, in evaluations done after the course was finished.

Students were excited by the opportunity to apply basic concepts to solving real world problems. Although most found that they spent more time on this course than on other courses, they felt the time spent was very worthwhile.

The students appreciated that they were working on a project together, rather than being in competition with each other. Particularly as the semester wore on, they met with each other outside of class, at their own initiative, to help each other solve particular problems.
They enjoyed finding that each person had particular strengths and weaknesses; the fact that the students came from different majors - urban studies, design, mathematics, and physical and social sciences - led them to realize the strength of an interdisciplinary team.
From the instructor's point of view, the following were some of the advantages over a more traditional course:
Students were able to see for themselves the limitations of a purely technological solution to the problem of weaning the United States off of fossil fuels; this is particularly true if one wants to avoid nuclear.
They were able to see how difficult it was to get reliable, accurate information as to the costs and land use requirements of alternative energy sources.
As a result, they were able to take a critical look at many of the statements made about the use of alternative energy. Many felt that the basic reporting on such issues in the media, and even by environmental groups, was woefully inadequate and in some cases misleading.
And, to repeat what the students felt, learning about an interdisciplinary approach to problem solving was important. Among the things they learned was that in order to fully participate in an interdisciplinary team, they had to have significant knowledge of the discipline they were contributing to the overall effort.

The course has several disadvantages. For one thing, it does require a bit more work on the part of the students than a more traditional course. As an academic advisor, I try to make sure that the student load is one that the student can carry, particularly since most of them have jobs to help them pay tuition (The New School has a significant scholarship program, but many students have to work anyway). Some of their jobs are quite demanding. Several students had to drop the course because of the workload.

Secondly, it is necessary for the students to have fairly sophisticated research skills to be successful. Most of the courses in the Environmental Studies Program at The New School emphasize these skills, so most students are pretty well prepared, but one must be careful to make sure this is true. An unprepared student would flounder pretty badly.

Thirdly, to get some of the necessary information required going to manufacturers themselves. Not every student has the skills, confidence and personality to be able to do this successfully; this is where many of the peer-to-peer conversations were very helpful.

Fourth, the course has to be the right size. Too few, and there are not enough researchers to sufficiently explore the technologies and techniques involved. Too many, and the course becomes unwieldy. The two courses had fourteen and sixteen students - the cap is eighteen students - which seemed to be about right.

Finally, grading is a problem. I could have made this a pass/fail course, but decided not to, and to give grades (many students do not like pass/fail courses). Judgements had to be made as to the quality of the research as well as of their presentations. There was a mid-term exam which tested their knowledge of basic concepts. All in all, students seemed satisfied with their grades.
In sum, despite the drawbacks described here, the course was considered a success by myself, the students, and the administration of the school. The students learned a great deal, more than they could from a textbook, and a number of significant learning objectives were achieved, more than would be true in a traditional course.

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Energy and Climate – Imperative Concepts for Tomorrow's Engineers

Keywords: climate, assessment, energy minor, literacy

Abstract

Clarkson University's undergraduate minor in Sustainable Energy Systems Engineering includes the expected technical courses to provide analytical and design thinking and tools, but also mandates that students take a policy and environmental impacts class to develop the systems-level insights needed for a new energy economy. Most of the students take a class on climate change designed specifically for engineering students to help provide this breadth. Engineers must take a leading role in addressing the challenges of creating a new energy economy to

mitigate climate change and adapt to the inevitable changes that our world is facing. Yet climate change classes that target engineering students are scarce. Technical education must focus on the problem formulation and solutions that consider multiple, complex interactions between engineered systems and the Earth's climate system and recognize that transformation raises societal challenges, including trade-offs among benefits, costs, and risks. Moreover, improving engineering students' climate science literacy will require educational strategies that also inspire students' motivation to work toward their solution. The climate science course for engineers has been taught 5 semesters as part of a NASA Innovations in Climate Education program grant (NNXlOAB57A). The basic premise of this project was that effective instruction must incorporate scientifically-based knowledge and observations and foster critical thinking, problem solving, and decision-making skills. Lecture, in-class cooperative and computer-based learning and a semester project provide the basis for engaging students in evaluating effective mitigation and adaptation solutions. Policy and social issues are integrated throughout many of the units. The objective of this presentation is to highlight the content and pedagogical approach used in this class that helped to contribute to significant gains in engineering students' climate literacy and critical thinking competencies. The quasi-experimental study examined the overall status of climate literacy and evaluates changes in students' climate-related content knowledge, affect, and behavioral attributes following completion of the semester course. The specific questions that the research aims to answer include: 1. How climate literate are engineering students? 2. Does this course increase their overall climate literacy (knowledge, affect and behavior sub-scales)? 3. At the end of the semester, do the students have the self-efficacy to effectively integrate climate change perspectives into their profession? 4. At the end of the course, have the students demonstrated that they have the technical and critical thinking skills and competencies to address climate change in their profession? The class made a difference in climate literacy. Before taking the climate change class, students had fairly low scores on all three climate literacy sub-scales, with only 20% of the students surpassing a knowledge "passing" rate of 70%. This is consistent with the generally low climate literacy among college students. Of the 89 students in this class fully participated in a pre/post climate literacy questionnaire over 4 years, students demonstrated significant gains ($p<<0.05$) in climate-related content knowledge, affect, and behavior. Mean post scores were above a 'passing' cutoff (>70%) for all three sub-scales. Several variables were considered to better understand the spread in student climate literacy. The most important (though not wholly independent) variables were whether the students had an introduction to climate change in a prior class and their gender. Mechanical Engineering students – most of whom were males who had not had a prior class that introduced climate, had the lowest initial affect and behavior scores, but the greatest amount of positive change as a result of the class. Their knowledge scores increased from 63 to 78 and affect scores increased from 65 to 72. Only their self-reported behavior scores remained below the 70% "passing" score. Assessment of semester project reports with a critical thinking rubric showed that the students did an excellent job of formulating problem statements and solutions in a manner that incorporated a multidimensional systems perspective. These skills are sometimes foreign to technically focused, number crunching engineering students, but are critical for using their engineering skills and profession to address energy challenges to mitigate climate change and strategies for adaptation. By conducting a thorough assessment of this class, it is clear that there is significant opportunity for improving the climate literacy of engineering students, especially mechanical engineering students who are predominantly male and otherwise do not get the breadth and systems level perspectives needed to address our need for a new energy economy.

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Energy Analysis, Policy, and Security: A Multidisciplinary Energy Elective Course at the US Naval Academy

Keywords: multidisciplinary, elective, security, current events, energy

Abstract

With the goal of studying not only "energy," but the links between energy, policy, and national security, a team of faculty at the US Naval Academy recently created a new interdisciplinary upper-level elective course. The US Naval Academy is one of the nation's military academies and serves as a primary commission source of officer-leaders for the US Navy and US Marine Corps. Graduates of the Academy step directly into leadership positions in those services. As such, these graduates are well-positioned to have influence over operational energy decisions within their units, and later on, to influence energy policy within the US Department of Defense (DOD) as more senior officers. The initial offering of the course involved a team teaching approach, consisting of both small and large group meetings, led by four faculty members from four different academic departments and disciplines: economics, mechanical engineering, political science, and oceanography. These four faculty members together directed course learning and discussion with individual emphasis on their respective core disciplines of economics, technology, policy, and environment. The course itself was broken into four general sections. After an introductory section covering the basics of energy, policy and security, there were three follow-on modules focused on fossil fuels, nuclear, and renewable energy. Students in the course were arranged into interdisciplinary teams (consisting of 4 students in each team) and were assigned a particular country on which to focus their analysis for the length of the term. Large group lectures led by the different faculty on a particular topic were followed by discipline-focused section meetings which allowed students to dive into deeper energy-focused discussions specific to their specific field. For example, in the nuclear section of the course, students in the political science section would focus on nuclear policy, economics students would examine the relationship to overall market energy prices, oceanography students would discuss environmental impacts of nuclear energy, and engineering students would focus on nuclear technologies. The interdisciplinary student teams would then come together to synthesize their thinking on their assigned country's energy portfolio, each bringing their own perspective to the group.

The main goal of the course was to empower students with high level, multidisciplinary thinking required to understand modern energy issues. For example, some technologies that make sense on an economic basis will not likely be possible from a public policy perspective. Understanding the political or economic landscape is often essential to choosing the best technologies for investment. Another goal of the course was to explore the links between national security and energy policy. In the context of security, energy efficiency has historically been a secondary priority to military readiness, but the landscape is changing, and readiness and efficiency are growing more inextricably linked. Modern military forces utilize more fuel than ever. In modern security scenarios, without a renewed focus on efficiency, operational readiness and security may be directly impacted. Fuel supply cannot always keep up with demand, and the long-term costs of inefficient energy utilization often outweigh the short-term benefits of less-efficient solutions. This presentation provides an overview of this new course, including the motivation, planning, execution, and lessons learned after its first offering.

This presentation will also summarize preliminary results of an extensive assessment of the course. Specifically, the assessment tests if the interdisciplinary nature of this course affects student attitudes and beliefs regarding energy at a deeper level than traditional single discipline courses. The effect of the interdisciplinary approach was tested using a pre- and post-test design, as well as control groups. The hypothesis under test was that interdisciplinary co-instruction (i.e., a single class taught by a team of instructors from different disciplines) increases the pro-social attitudes of trust and cooperation in students, as these attributes are built into the act of successful interdisciplinary co-instruction (Holley, 2009) and modelled to students in the interdisciplinary classroom. The study further hypothesizes that gains in pro-social attitudes will translate into positive attitudes regarding energy conservation and environmental protection, as the literature has found a connection between trust and pro-environmental attitudes (Konisky, Milyo, and Richardson, 2008). In sum, the study hypothesizes that the act of interdisciplinary, co-instruction will increase student trust and cooperation and lead to pro-environmental attitudes among students, even when these attitudinal changes are not direct learning objectives of the course. The pre- and post-test results from students in this course were compared with two other traditional and non-interdisciplinary courses: a political science course and an engineering course covering energy topics. The initial results indicate that the course may not have impacted pro-social attitudes as predicted in the hypothesis. However, students in the interdisciplinary course were more likely to have increased concerned about energy issues, more likely to recognize the energy and security link, more likely to support government actions to address energy problems, and were less likely to support candidates who reject climate science. These results were statistically significant when compared to pretest results and to the post test results of the control groups. The interdisciplinary course also moderated student's political ideologies and clarified the link between political ideology and specific energy policy preferences. . In sum, the course helped students understand their views on energy and better articulate these views in line with their own political views.

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Introductory Energy Education Framework with Topic-Based Modular Course Design

Keywords: Energy education, course design, core curriculum, socioeconomics, sustainability

Abstract

Introduction to energy has been incorporated in educational curricula at all levels as a result of the key role energy plays in the modern society and the high importance of energy literacy. Courses in introductory energy education typically expose students to the entire spectrum of energy technologies by surveying the technological landscape of the industry (e.g. through a sequence of topics including fossil energy, hydropower, wind, solar), and by examining each energy technology within its respective developmental and regulatory context. This approach, although intuitive and well-developed, is flawed in its portrayal of energy technologies as independent and mutually exclusive choices. Such an approach frustrates students with the complexity of energy-related factual knowledge, and renders the multidisciplinary essence of energy education elusive.

We tested a new framework for the teaching and learning of energy-related topics by designing courses that focus on multidisciplinary energy education rather than dissemination of factual energy knowledge. Our innovative coursework highlights the impact of energy technologies, both renewable and non-renewable, within a number of socioeconomic and environmental dimensions. In our latest offering of a newly developed introductory energy course, Energy Technology and Social Change, we present energy as a key driving force for social, economic, and technological evolution within human society. Students analyze energy technologies from various eras of human history, and identify the key role energy plays in shaping human society as a whole. Under this new framework, students learned how to conduct value judgements based on characteristics of energy technologies, and became able to perform holistic assessment of emerging energy technologies that are augmenting or replacing existing technologies.

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A Cloud Enabled Virtual Reality Based Pedagogical Ecosystem for Solar Energy Education

Keywords: Virtual Reality, Solar Energy Education, Internet of Things, Cloud Technology

Abstract

This presentation describes a scalable and transferable cloud-based virtual reality pedagogical ecosystem that provides students with the basics of solar cells, panels, and arrays. The module uses mathematical models derived from the experimental solar cells, arrays, and panels to incorporate realistic solar energy behavior. Students are able to design and modify a virtual solar panel for optimal energy generation by modifying individual wind solar cell parameters such as the number . Live graphs showing how the design parameters affect total power output from the virtual solar array provide instant feedback to the students. An adaptive methodology that assesses the application of students' independent thought processes, along with design and operational skills in creating the solar arrays is implemented. As educational VR systems continue to develop, we anticipate that cloud based implementations will be utilized for an increasing number of educational needs and that the ecosystem and technical approach presented in this paper may serve as a guide for future educational VR research.