TEACHING SUSTAINABILITY USING A FOCUSED MULTI-DISCIPLINARY APPROACH

PODUČAVANJE ODRŽIVOG RAZVOJA KORIŠTENJEM USMJERENOG MULTIDISCIPLINARNOG PRISTUPA

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Summary

The myriad definitions and measures of sustainability complicate the development and teaching of an introductory sustainability course. The United Nations' Brundtland Report provided a definition for sustainable development and John Elkington and others modified the concept with the Triple Bottom Line, which sought to balance environmental stewardship, economic growth and social responsibility. Sustainability's growing popularity and relevance to many academic majors compelled course developers to create multi-disciplinary courses that are relevant to many academic disciplines. During the development of a course on sustainability, University of Houston and Colby College course developers believed the main challenge for effective pedagogy involved effectively intertwining the complexity of sustainability with an applied focus in a multi-disciplinary classroom. In this case, the course developers choose a specific policy focus – energy in this case – to explore sustainability's complex and multi-disciplinary nature. With this specific analysis, the students were then able to apply these new skills to other sustainable policy programs. Additionally, the explicit multi-disciplinary character of the classroom allowed the professors and the students to bring their strengths and use them to increase the awareness of the importance of the multi-disciplinary approach to solve problems.

Key words: Sustainability, Energy, Multidisciplinary, Sustainability Pedagogy
Ključne riječi: održivost, energija, multidisciplinarnost, pedagogija održivosti

When preparing a course on sustainability, course developers must consider the complicated nature of the term sustainability. Sustainability or sustainable development can be thought of as a radial category, a term philosophers use to characterize a word or idea that has an imprecise definition categorized by a range of concepts rather than universally accepted, explicit rule.[1] The word sustain originated in the 13th century and sustainable can be traced to the 17th century; therefore to tie sustainability to a single meaning proves problematic. The introduction of the term in the Brundtland Report and its inclusion in corporate governance documents as an integral part of the Triple Bottom Line further problematizes the term.[2] With the inexact nature of sustainability and sustainable development, myriad indices have been created to measure and compare sustainability actions performed by governments, non-governmental organizations and corporations. These indices incorporate measurements from other radial categories including health,

[1] Lakoff, George and Mark Johnson. *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. New York: Basic Books, 1999. print.

[2] United Nations. *Our Common Future*. Ed. World Commission on Environment and Development. Oxford: Oxford University Press, 1987.

poverty and environmental protection. The imprecision and immensity of sustainability and its measures challenges teachers as they develop courses that give students from myriad disciplines the ability to make and analyze sound assessments of sustainability. The paper will explore the process, successes and challenges encountered during the development and teaching of an introductory sustainability course.

In 2004, the United Nations declared the next ten years as the Decade of Education for Sustainable Development. Additionally, in the last ten years, corporations have established extensive sustainability programs based on the Triple Bottom Line. With this increased attention, more academic institutions created courses and academic programs with sustainability education as one of the core objectives. The Association for the Advancement of Sustainability in Higher Education (AASHE) Academic Program database contains 1,415 sustainability-focused academic programs at 465 campuses in the United States and Canada.[3] In one example, the University of Illinois created a massive open online course (MOOC) that covered general aspects of sustainability and its intersection with natural resource and pollution abatement policies.[4] The MOOC included Brundtland Report policy areas such as ecosystem services, energy and agriculture while covering the Triple Bottom Line. Other universities directed their sustainability curriculum primarily to science and engineering students.[5] We wanted to create a multi-disciplinary sustainability course that would be relevant to many, if not all, academic disciplines but also allowed the students to look deeply at a specific aspect of sustainability so they could learn how to effectively assess sustainability measurements, statements and actions. This paper will concentrate on the development of content and assignments since the newness of the course has not allowed for a consistent method of assessing student learning.

Our main pedagogical challenge involved effectively intertwining the complexity of sustainability with an applied focus in a multi-disciplinary classroom.[6] We met the challenge by narrowing the focus of the course to review and analyze sustainability from a specific policy category. A specific focus allowed the students and professors to consider one policy category and investigate its definable concepts while exploring sustainability's complex and multi-disciplinary nature. We chose energy as our policy category and named the course, Energy & Sustainability. Additionally, choosing one policy category reduced the number of concepts introduced to the students and gave them the ability to defensibly make and analyze assessments of sustainability. The specific policy we analyzed was based on students' interests and the strengths of the university and college and the professors leading the course.

With energy chosen as the specific category, we determined that it was important to situate the concepts of sustainability and sustainable development into recent history since most students enter the classroom with some knowledge of sustainability from their respective disciplines. We provided a common foundation for the students beginning with a chronology of its formation from pre-*World Conservation Strategy* concerns about natural resources depletion and pollution abatement through the attempts to create a unified definition to its myriad measures and uses in the 21st century. This introduction allowed the students to understand that sustainability has myriad definitions and measures, which makes the analysis of outcomes complex.

Third, we believed that introducing concepts from a specific policy category would give the students a basis for recognizing the complex interconnections within the definition of sustainability but in a focused manner. Sustainability transcends individual disciplines and requires social scientific and scientific tools;

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3 These data were accessed from the Association for the Advancement of Sustainability in Higher Education website on June 18, 2014. (http://www.aashe.org/resources/academic-programs/)

4 Information on the course developed by the School of Earth, Society and Environment at the University of Illinois can be found at http://www.earth.illinois.edu/class.html.

5 Littledyke, Michael, and Evangelos Manolas. "Ideology, Epistemology and Pedagogy: Barriers and Drivers to Education for Sustainability in Science Education." *Journal of Baltic Science Education* 9.4 (2010): 285-301. Print.

6 Sustainability has been described as a multi-disciplinary, interdisciplinary or trans-disciplinary subject. The use of the multi-disciplinary is intentional since the instructors' goal was to address the methods each discipline with minimal discussion on each discipline's methods. See Remington-Doucette, Sonya M, et al. "Assessing Sustainability Education in a Transdisciplinary Undergraduate Course Focused on Real-World Problem Solving. A Case for Disciplinary Grounding." *International Journal of Sustainability in Higher Education* 14.4 (2012). for a discussion of the terms.

therefore, introducing energy-related concepts allowed the students to understand energy policy's language and gave them the ability to converse with decision makers and critically analyze their decisions. Although the course concentrated on one policy category, it provided the students with the tools needed to approach the problematic nature of sustainability while recognizing that many disciplines took part in the development of our present understanding of sustainability. Therefore, having a multi-disciplinary classroom with students from economics, political science, ecology, biology, sociology, anthropology, history, chemistry and myriad other disciplines broadened and deepened the analysis. Whether addressing sustainability using energy or clean water or a livable wage as the focus, the challenge to meet present and future human needs in a sustainable manner must be analyzed from many perspectives. Introducing the concepts of the chosen policy focus permitted the students to use their background and opened the students to a multi-disciplinary perspective. We decided that the introduction to energy consumption and use must be a stand-alone, in-depth description and explanation of energy concepts. Since sustainability analysis tends to be comparative, an extensive primer on basic concepts of the chosen policy provided the student the tools to analyze how organizations have worked through their decision making processes to chose a specific sustainable energy program or policy.

Fourth, we understood that describing the course as a multi-disciplinary course that required learning new concepts allowed students at all levels to acknowledge that they will be studying concepts that their colleagues may not consider as new. Moreover, it gave students license to ask basic questions and gain insight into how other disciplines approach and solve problems.[7] With a multi-disciplinary approach, students took these new ideas and incorporated them into critically analyzing and developing ideas to create more comprehensive solutions to sustainability policy.

CREATING ENERGY & SUSTAINABILITY: A CASE STUDY

When the University of Houston (UH) considered developing a minor that covered sustainability, its majors, departments and schools came together to create a minor that combined sustainability with one of Houston's strengths – energy. Texas, Houston and UH is embedded in the prevailing international fossil fuel industry and emerging renewable energies including solar and wind energy.[8] Additionally, many UH students major in petroleum engineering or have connections to the energy sector through family, work or internships. As part of the minor, UH developed a multi-disciplinary introductory sustainability course on energy and sustainability. The course design revolved around the closely related issues involving energy, the environment, society and the economy. More importantly, with global warming becoming the primary environmental concern, UH believed that its content would be beneficial for students interested in professional and academic careers in almost every discipline. In addition, the course could be taught at other universities and colleges.[9] The course analyzed the far-reaching choices the world community faces, including the types of energy we use, the quality of the environment in which we live, and the global economy in which we work. The course examined these choices and their long-term implications. Finally, it provided the students tools to analyze the current and emerging global energy industry and examine the challenges to the creation of a sustainable energy future. The course introduced issues important to the future of energy, including energy consumption patterns, current and emerging energy sources, conservation, and climate change. The course had the following learning outcomes:

- Explain the history of energy production and use
- Understand emerging energy sources
- Integrate energy's role with global economic, social and political issues

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[7] Marinova, Dora and Natalie McGrath. A transdisciplinary approach to teaching and learning sustainability: A pedagogy for life. In *Seeking Educational Excellence.* Proceedings of the 13th Annual Teaching Learning Forum, 9-10 February 2004. Perth: Murdoch University. http://lsn.curtin.edu.au/tlf/tlf2004/marinova.html.

[8] Brannstrom, Christian, Wendy Jepson, and Nicole Persons. "Social Perspectives on Wind-Power Development in West Texas." *Annals of the Association of American Geographers* 101.14 (2011): 839-51. http://dx.doi.org/10.1080/00045608.2011.568871.

[9] I was hired as a visiting faculty to assist in its development and to then take the course and modify it for other institutions.

- Analyze patterns of energy consumption
- Analyze connections between energy use and environmental issues, including climate change
- Develop and communicate strategies to create a sustainable energy future

The course stressed the history of energy consumption and production, the concepts underpinning energy use and conversion and the importance of finding multi-disciplinary solutions to creating a more sustainable future. The course continues to be taught to UH and was taught at Colby College in fall semester 2013. The two versions of the course brought students from many academic disciplines and countries together in the classroom. Economics, chemistry, biology, ecology, environmental studies, petroleum and civil engineering, business, anthropology, history, geology, physics and political science among others have been represented in the course. Additionally, UH and Colby College students had familial and cultural connections to Asia, Europe, Africa, South and Central America, the United States and Canada. The challenge for course developers included creating content and assignments to achieve learning outcomes and developing assessments to determine key competencies in a diverse and multi-disciplinary classroom.

COURSE CONTENT

The course content flowed from the learning outcomes. Beginning with the need to create a foundation for effective analysis of conventional and emerging energy sources, we considered what concepts were needed for the students to defensibly make and analyze the sustainability of energy sources. Understanding that calculating energy consumption and transfer has standard formulas and concepts, we concluded that the students should be introduced to the forms and types of energy and the basic principles of thermodynamics. For a course on agriculture or biodiversity, other social science or natural science concepts should be identified and introduced. Since many students had not taken a college chemistry course, we focused the concepts on defining, measuring, and identifying the forms (thermal, nuclear, mechanical etc.) and types (kinetic and potential) of energy. This information proved useful when determining why heating is a more efficient use of fuel than electricity generation. Electricity generation requires additional transfers of thermal energy into mechanical energy and electrical energy.

Using the principles of thermodynamics the students were able to recognize that the transfer of energy from one form to another form always involved energy losses. The first and second laws of thermodynamics showed the students that understanding specific concepts from other disciplines could provide insight to making policy decision. Specifically, knowing that energy can be neither created nor destroyed; just transferred to other forms of energy and comprehending that the transfer of energy cannot be 100 percent efficient provided new tools for the students. The knowledge allowed the students to reject pronouncements about potential energy sources that boast they generate more power than were put into them. Additionally, students could discuss the relative inefficiencies of electricity and heat transfer while analyzing emerging energy sources. At first, non-science based students were skeptical of the basic chemistry instruction but as they began in-depth analyses of nuclear energy, fuel cells and other aspects of energy consumption and production some students suggested we add additional chemistry modules.

As we reviewed thermodynamics, the chemistry, physics, biology and engineering majors assisted in making the science applicable to the other majors. But more importantly, the non-science majors asked questions about the primacy of science in decision making, which showed the science students that energy policy decisions should include non-science based information and analysis. With a multi-disciplinary classroom, the students stressed through their questions and critical thinking that each discipline provided information for better evaluation. They agreed that knowing the science behind the energy choices helped with the articulation and assessment of alternative energy sources but the multi-disciplinary approach provided the better analysis.

After we introduced the basics of energy, we provided the students with a primer on sustainability and its uses in the late 20th and early 21st century. We used the Brundtland definition as a starting point. But we also wanted the students to understand that although the Brundtland Commission worked to create a useable definition, the report contains myriad information collected and synthesized during the commis-

sion's existence. We noted that from 1984 to 1987, the Commission held thirteen public hearings on five continents and received over 800 written submissions. With these disparate and numerous stakeholders weighing in, the students began to understand that developing a definition of sustainable development or sustainability proved challenging.[10] Regardless, the commission did create a definition of sustainable development and a report that detailed the policy challenges and solutions to address natural resource deterioration and pollution abatement using international, regional and national governance approaches. The history allowed the students to recognize how the imprecise definition of sustainability problematized the goals and outcomes of the Conference on Environment and Development in Rio de Janeiro in 1992 and subsequent meetings in 1997, 2002 and 2012.

Moreover, we wanted the students to recognize that corporations also took up the challenge of defining and measuring sustainability. We explained that as governments began to strengthen environmental protection laws and regulations, corporations began to consider sustainability issues in conjunction with their desire to limit environmental regulation.[11] John Elkington's Triple Bottom Line recognized that corporate success should not only be measured by the traditional bottom line of financial performance but also by its effect on the local, regional and global economy, environment, and society. The Triple Bottom Line provided framework for corporations to balance the dimensions of environmental stewardship, economic growth and social responsibility.[12] We provided the students with two sustainability plans so they could critically analyze how corporations have developed and created sustainability and corporate responsibility programs to promote their sustainability successes.[13] With these examples, the students were able to understand that the Triple Bottom Line provided a vague and almost immeasurable definition of sustainability.

With the students beginning to appreciate the inexact nature of sustainability and sustainable development, we introduced myriad indices used to measure and compare sustainability actions performed by governments, non-governmental organizations and corporations. These indices incorporated measurements from other radial categories including health, poverty and environmental protection. Some indices attempted to create a numerical standard to gauge the success or progress of an organization's sustainability activities. We used Christian Böhringer and Patrick Jochem analysis of eleven indices. In their study, they showed that each index attempts to provide a one-dimensional metric (a single number) that incorporates the three categories of sustainability – economic progress, environmental protection and societal conditions.[14] The paper showed that more than 500 individual indicators, such as access to clean water, life expectancy, etc. could be included in measuring sustainability.[15] With this complexity, Böhringer and Jochem analysis revealed that the eleven indices failed to provide an adequate sustainability measure. In addition to failing to calculate coherent numerical standards, the students noted that the indices only use between three and seventy-six individual indicators. For example, the Ecological Footprint used primarily water and energy consumption data to determine the quantitative land and water requirements to sustain a specified living standard, ignoring the social aspects of sustainability. On the

[10] When the course was taught, a history of the Brundtland Commission had not been written. In January 2014, the first history of the Commission was published. Borowy, Iris. *Defining Sustainable Development for Our Commons Future: A History of the World Commission on Environment and Development*. New York: Routledge, 2014.

[11] Sale, Kirkpatrick. *The Green Revolution: The American Environmental Movement, 1962-1992*. New York: Hill & Wang, 1993. Print. Rothman, Hal K. *The Greening of a Nation? Environmentalism in the United States since 1945*. Fort Worth: Harcourt Brace College Publishers, 1998. Print. Gottlieb, Robert. *Forcing the Spring: The Transformation of the American Environmental Movement*. Washington DC: Island Press, 2005. Print. Hays, Samuel P. *Beauty, Health and Permanence: Environmental Politics in the United States, 1955-1985*. Cambridge: Cambridge University Press, 1987. Print.

[12] Elkington, John. *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. New Society Publishers, 1998.

[13] The author has authored and co-authored Sustainability Reports for both corporate and government organizations using the Triple Bottom Line. Two examples of sustainability reports include *Royal Dutch Shell PLC Sustainability Report 2012*: Royal Dutch Shell PLC, 2012. and *Corporate Citizenship Report*: ExxonMobil, 2012.

[14] Böhringer, Christoph, and Patrick E. P. Jochem. "Measuring the Immeasurable — a Survey of Sustainability Indices." *Ecological Economics* 63.1 (2007): 1-8. Print.

[15] Babcicky, Philipp. "Rethinking the Foundations of Sustainability Measurement: The Limitations of the Environmental Sustainability Index (ESI)." *Social Indicators Research* 113.1 (2013): 133-57. Print.

other hand, the Human Development Index compiles societal data on life expectancy, education and gross national product to develop its values.

We stressed that the measures tend to be comparative in nature; therefore, the numbers need to be reviewed critically in the context of their chosen indicators. The scores are weighted and aggregated to determine a cumulative score; the higher the score the more sustainable the organization compared to other organizations.[16] We also introduced another more straightforward and comparative strategy that involved calculating per capita reductions in energy consumption, water use and hazardous waste disposal or per capita increases in recycling, wages and access to health care based on a baseline year. The students were able to discern that each of these examples did not take into account the wide range of sustainability nor did they create a standard to achieve. Instead they revealed the problems with sustainability measures that attempt to quantify sustainability based on established standards and data. In effect, an absolute number cannot be calculated for any sustainability indicator. Sustainability indices can only compare decisions, actions and organizations to other decisions, actions and organizations to determine greater or lesser sustainability success. In the classroom, students easily saw the limitations of the measures, which caused them to express frustration and question their legitimacy for measuring and understanding sustainability. Introducing the multiple definitions of sustainable development and sustainability and sustainability metrics gave the students the tools to critically analyze the concepts introduced throughout the remainder of the course. Like with the energy concept introduction, the students comprehended that understanding the specifics of the measure used could be more important than the actual results.

After introducing the general history and basic concepts of sustainability and thermodynamics, we searched for a central text for the course. Because it was a fairly new course of study and its reach was extensive, we found few sustainability textbooks that were applicable for course use. For an introductory class, we thought that having a central document that assists the professor in guiding the narrative and provides basic material could be helpful. The University of Illinois Sustainability MOOC had a free online textbook but we considered it too general and broad in scope. In the course's first incarnation, we did not have a central text for the students since few general textbooks had been published at that time. In their evaluations, UH students reflected that a central text would have helped with organizing and understanding the trajectory of the classroom instruction. Therefore, in its second incarnation at Colby College finding a central text became an important objective. By summer 2013, many textbooks had been published on sustainability but we were unable to find one that met the objectives of the course. After reviewing textbooks, we chose the documentary, *Switch*, created by University of Texas Geology Professor Scott Tinker. The film reviewed current and future energy sources and considered their sustainability for the future. Specifically, the documentary asked the question, »Just as it did in the West, coal will power the development of China and India, but it will not be clean, oil demand will increase and so will risk and so will price. The challenge then is not to just adopt alternatives but to maintain the benefits of oil and coal without their disadvantages and at a price we all can afford. Can it be done?« From this question, Tinker examined energy sources by visiting Texas wind farms, the Alberta Oil Sands, California solar arrays and Dubai natural gas installations and asks questions about their future. The visual introduction to open pit coal mines, geothermal installations and offshore oil platforms along with other energy source locations gave the students insight into the reality of 21st century energy production.[17]

From this central film, we created the structure of the course and determined the additional readings. With the plethora of new textbooks and the increasing media attention on energy and sustainability issues, we knew that situating the present energy situation in history was the an important next step for the students. Questions included; how did oil and coal become primary energy sources? What is the current status of alternative or non-traditional energy sources in the United States and the world? What infrastructure is needed for the existing energy sources? Again, the multi-disciplinary classroom guided

[16] Böhringer, Christoph, and Patrick E. P. Jochem. "Measuring the Immeasurable — a Survey of Sustainability Indices." *Ecological Economics* 63.1 (2007): 1-8. Print.

[17] *Switch*. Dir. Harry Lynch. Arcos Films, 2013. Film.

our decisions. The students read primary and synthetic history journal articles on domestic coal and international oil production and highway construction.[18] Since we wanted the students to gain the ability to understand policy and scientific documents, we used publications from the US Environmental Protection Agency (USEPA) on coal and oil pollution control technology and from the US Energy Information Agency (USEIA) on current and future domestic and international energy use. Finally, to help the students understand that energy regulation has a rapidly changing landscape, we spent an entire day on the revised regulations for greenhouse gas emissions from fossil fuel based electrical generation stations and the media attention surrounding them.[19] We reviewed the technical requirements of the standards and the process of developing regulations from established laws and court decisions while evaluating the criticism from the coal industry and the effectiveness of the revised regulations. We believed that this exercise allowed the students to see in real time how energy policy is created and shaped by the media, lobbyists, and the government. The students agreed and were appreciative of the in depth introduction to carbon sequestration and the federal register.

Table 1: Emerging Energy Sources and Energy Uses

Energy Sources	Hydropower
	Biofuels
	Conventional Natural Gas
	Non-conventional Natural Gas (Fracking)
	Oil Sands
	Geothermal
	Nuclear
	Wind
	Solar
	Tidal
	Fuel Cells
Energy Uses	Transportation
	Buildings

Source: ES 297 Energy & Sustainability Syllabus Colby College, 2013.

From basic energy and sustainability concepts and the history and present status of energy policy in the United States and the world, we then moved to an thorough analysis of emerging energy sources and energy uses (Table 1). For each of the topics, we covered the following aspects; technology basics, history, economic, environmental and social costs, case studies, regional issues and US government policy, if applicable. Readings ranged from social scientific articles reviewing biofuel production in Brazil to promotional material from the Alberta Treasury Board on oil sands to a history of atomic energy from 1945 to 1985 to a Leadership in Energy & Environmental Design (LEED) Checklist. Invariably, we used information created by the USEIA assisted in creating the story for each energy topic. Although, we confronted the criticisms of the projections and analysis of the USEIA-produced information, we could not argue with the collected data on international energy production and domestic consumption. This government agency gave the students raw data for their presentations and other assignments.

Moreover, the variety and age of the assigned readings gave the students insight into the history of alternative energy policy. For example, the use of a Saturday Night Live skit from April 1979 entitled »The Pepsi Syndrome« pertaining to the Three Mile Island accident and an August 2013 Colbert Report segment on non-disclosure agreements for fracking lawsuits showed the students that these questions and solutions have been the subject of satire for decades. Looking at the growth of solar power in Germany, we explored popular media's critique of how the high cost of its expansion falls primarily on the poor. This analysis gave the students a chance to ponder the some of negative social aspects of emerging energy sources. In another case, on the 50th anniversary of the assassination of John F Kennedy, we read his remarks on the potential use of tidal power for electricity production in Maine. Kennedy's enthusiasm for tidal power mirrored the enthusiasm for this energy source in today's media.[20] It forced the students

[18] The ability to find an accessible article on the history of the grid proved challenging. We used a National Public Radio series on the electricity and a promotional piece from the North American Electric Reliability Corporation. We believe that *Technology & Culture* or *Environmental History* should commission a piece on the development of the grid in the United States.

[19] The EPA published the draft Standards Of Performance For Greenhouse Gas Emissions From New Stationary Sources: Electric Utility Generating Stations in September 2013.

[20] In Maine, tidal power is seen as a way for Maine to move away from wood as the primary energy source. Kennedy, John F. "Remarks in Response to a Report on the Passamaquoddy Tidal Power Project.," July 16, 1963. Online by Gerhard Peters and

to realize that we have been promised a solution to the hegemony of oil and coal for energy for over 50 years. Therefore, they realized that sustained research and development funds and subsidies for alternative energy sources may assist in the transition from oil and coal to other energy sources.

In each of the sections on specific energy sources and topics, the learning outcomes were the guiding principles. We took an applied approach for analysis. We wanted the students to integrate and analyze the energy sources and their costs and benefits. In the case of hydropower, we used an established sustainability assessment protocol developed by the International Hydropower Association. This tool allowed the students to investigate how an industry created its own tools and to consider how other energy industry groups develop tools. Specifically, we covered the different stages of energy generation in hydropower development. The protocol covered planning, design, construction and operation, which gave the students the ability to grasp that traditional energy sources like oil, coal and hydropower can increase their sustainability indices long after infrastructure construction.

COURSE ASSIGNMENTS

We found the biggest challenge was the speed of new discoveries and information on energy sources including technology changes and social costs. Although this is true for most courses, the amount of new research and papers on energy and sustainability meant that the reading list changed substantially from semester to semester. The reading lists for the two versions of the courses contained little duplication. When teaching sustainability, it is important to keep the information as up to date as possible. To keep the students aware of the changing nature of energy and sustainability, we instituted an assignment that was met with considerable enthusiasm from the students. We asked the students to search journals, newspaper, government agency, energy industry and think tank websites and other information sources to find articles relevant to the topic covered during each particular class period. Students received credit for articles submitted with a synopsis and extra credit for the most relevant submitted article. The articles were required to be submitted before midnight on the day after the class. Of course, reviewing articles on a regular basis (and just prior to class) required a substantial time commitment on the professors; we found that reviewing the articles and discussing them at the beginning of the next class enhanced the multi-disciplinary nature of the classroom. We also published a list of articles on the course's website with the student generated synopsis. We learned that the students tended to search within their discipline, which provided additional details on how each discipline analyzed energy and sustainability. This was especially important since it introduced the professors and students to different points of view. For example, two economic students submitted articles detailing that additional US production of natural gas would not necessarily provide energy independence and less reliance on foreign energy sources. Their articles showed that natural gas companies would expand their export amounts because of better profits from exporting natural gas in the short term. Because of time constraints, this issue was not discussed in class but we were able to cover it the next day. Many conversations between the students originated from these articles. It also allowed students who were actively involved with climate change issues to submit articles from a variety of groups, including climate change skeptics.

Since we wanted the students to be able to communicate to the general public, policy makers and others, we incorporated the presentation of information as an integral part of the course. In the 21st century with the advent of YouTube and other video based platforms, we wanted the students to have a chance to convey their knowledge to the public and decision makers in a public space. Since we understood that the students needed to do more than just present information, in its incarnation at Colby College we asked the students to teach on a particular energy topic. We formed groups of two students and required them to create an informal lesson plan for approval. The lesson plan needed to be connected to the course's learning outcomes and the required aspects – technology basics, history, case studies, regional issues and US government policy. We made certain that the students were from different disciplines so that they

John T. Woolley, *The American Presidency Project*. http://www.presidency.ucsb.edu/ws/?pid=9344.

could provide different viewpoints while incorporating multi-disciplinary ideas. As one of the first student groups noted, »giving a presentation is easier than teaching a class. Teaching is a different skill set.« Of course, the students brought their disciplinary strengths and own interests to the lesson. For example, when covering non-conventional natural gas (fracking), the student group used a personal experience as the case study. One member grew up in central Pennsylvania over the Marcellus Shale Formation that is now being exploited for natural gas production. She discussed how her family had complicated views of the fracking. In an area of high unemployment, the fracking brought jobs to some family members but other members believed that the fracking would be harmful to the area in the long term. She and her partner asked the students to take part in a debate on the pros and cons of fracking. She was able to incorporate viewpoints that had been articulated during public hearings in her community.

Because of the prescriptive nature of the presentation, the students incorporated basic thermodynamic principles when discussing the energy sources' technologies. This forced the students to acknowledge that understanding energy consumption and production required computational skills along with the ability to compare the economic, environmental and social issues. To this end, the students acknowledged why so many leaders consider nuclear energy a viable option for a sustainable energy future. Its energy density and the small footprint of a nuclear power plant can overshadow the catastrophic aspects of a malfunction and the long-term problems with waste disposal. For example, they stressed that uranium has 580 gigajoules per kilogram compared to 29 megajoules per kilogram of coal. This fact along with large reductions in greenhouse gas emissions and other pollutants when compared to oil and coal can make nuclear power a more sustainable choice when compared to the status quo. Of course, they commented on the problems with nuclear plant accidents specifically discussing the issues of transparency in the government responses to Three Mile Island, Chernobyl and Fukushima.

To assist the students with their lessons, we also created an active participant assignment for two additional students. The active participants were required to work with the presenters and provide assistance, if needed. We found that this lessened the stress for the student presenters since they had students they could point to for clarification or to help lead any discussions. Students used the active participants in many ways. For the fracking debate, the active participants were the organizers for the debate. Others spoke up when the presentation lagged or added additional information not included in the presentation. Also, it showed that having a knowledgeable audience can make for better transmission of information and better analysis.

CONCLUSION

Developing an introductory sustainability course requires planning and focus because of the radial nature of sustainability. When preparing the course *Energy & Sustainability*, we determined that that narrowing the focus to one policy category and introducing and reviewing concepts from the policy category gave the students the ability to defensively make, analyze and assess sustainability decisions. With this experience, we believe the students will be able to take the new skill and apply it to other sustainable policy programs such as clean water or living wage policy. Additionally, we worked to create assignments that incorporated the multi-disciplinary nature of the students and the changing ideas of both our chosen policy category and sustainability. The assignments gave the students the ability to converse and engage with the emerging literature, opinion and science. Finally, we embraced the explicit multi-disciplinary character of the classroom, which allowed both the professors and the students to bring their strengths into the classroom and use them to increase the awareness of the importance of the multi-disciplinary approach to solve problems. [21]

[21] I would like to thank Joseph Pratt and Ognjen Miljanić who co-taught the Energy & Sustainability course with me at the University of Houston. I also want to acknowledge the assistance of Frank Kelley, Associate Dean of UH's Bauer Business School who supplied classroom space and administrative assistance during the development of the course and the Energy & Sustainability minor.

SAŽETAK

Bezbrojne definicije i mjere održivosti kompliciraju razvoj i podučavanje osnova održivog razvoja. Izvješće posebne izaslanice Ujedinjenih naroda Gro Harlem Brundtland daje definiciju održivog razvoja, ali su John Elkington i drugi taj koncept modificirali kao trostruku ravnotežu upravljanja okolišem, gospodarskim rastom i društvenom odgovornosti. Rastuća popularnost održivosti i relevantnost u mnogim akademskim disciplinama primorala je tvorce kurikuluma na stvaranje multidisciplinarnih studija, važnih u mnogim akademskim disciplinama. Tijekom razvoja studija o održivosti, tvorci kurikuluma na sveučilištima Houston i Colby College shvatili su da je glavni izazov za učinkovito podučavanje o ovome kako uspješno spojiti kompleksnost održivosti sa ciljanim obrazovnim sadržajima nekog multidisciplinarnog predavanja. U ovom su slučaju tvorci kurikuluma izabrali ciljani smjer, usmjeravajući fokus na istraživanje kompleksne prirode i multidisciplinarnost održivosti razvoja. Učeći o ovakvoj usmjerenoj analizi održivosti, studenti su naučili kako primijeniti ova nova znanja i vještine u drugim nastavnim predmetima koji se bave politikom održivog razvoja. Osim toga, eksplicitni multidisciplinarni karakter ove nastave omogućio je profesorima i studentima da otkriju svoje unutarnje vrijednosti i prednosti, te ih iskoriste za povećanje svijesti o važnosti multidisciplinarnog pristupa u rješavanju problema.

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