AC 2011-23: AN MULTIDISCIPLINARY ENERGY BASED CURRICULUM

C.S. Chen, Miami University

Dr. C.S. Chen is a professor and founding chair of electrical and computer engineering (ECE) department at Miami University (Ohio). He was the electrical engineering department head and the interim engineering dean at the University of Akron.

Steven Elliott, Miami University Dept. of Economics

Dr. Steven Elliott is an Associate Professor in the Department of Economics at Miami University. He has been a research associate at Oak Ridge National Laboratory before entering academics. His professional interests include energy and environmental economics and behavioral economics.

Mark Boardman, Miami University

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An Multidisciplinary Energy Based Course
Abstract

This paper describes the development of multidiscipline-based energy policy course at Miami University in Ohio. It addresses the development of interdisciplinary approaches to energy policy. This course requires students to think critically about the history of the development of carbon fuels; the dependency of world economic cycles on such fuels; alternatives that might be available in the future; and the scientific, engineering and policy challenges to their adoption.

In this course, students are engaged with others across disciplines. This interaction serves to enhance peer-to-peer education and build knowledge among student cohorts. The group projects and debates enhance students’ knowledge and oblige them to analyze problems from multidisciplinary perspectives.

The development and teaching of this multidisciplinary course presents challenges to the students and faculty in crossing the traditional academic silos. Lessons learned and the necessary institutional infrastructure in sustaining the multidisciplinary efforts are presented and discussed.

Introduction

Energy is not only an economic and technological issue; it is also an environmental and national security issue. The Department of Energy reports that the United States consumes about 100 quadrillion BTUs annually of energy, which is about a quarter of the global consumption. The U.S. produces about three quarters of the energy it consumes and imports the rest. The high U.S. energy consumption and overreliance on foreign imported oil have not only contributed to climate change and the financial crises, but also national security concerns.

Based on current consumption patterns, some experts estimate that we could run out of fossil fuel reserve within the next 50 to 100 years. Although nuclear power plants are now in their fifth generation and have solved innumerable technical problems, there are lingering technical problems with storage, recycling and leakage, and political barriers to adoption. Biofuels are harmless, but use the land and water inefficiently. Wind, wave and solar power, as currently configured, cannot yet replace petroleum for efficiency of energy produced; and ethanol, which receives the lion’s share of subsidies for renewable energy from the U.S. government, is one of the least efficient biofuels.

Addressing these and other similar issues requires a multidisciplinary approaches in business, natural and social science, engineering, and public policy. The federal government recognizes the need for such a multidisciplinary approach. In March 2010, the Department of Energy’s National Renewable Energy Laboratory (NREL) announced the establishment of a Strategic Energy Analysis Institute. The Institute aims to utilize the best available tools and the most credible data to guide energy investment and policy. Its vision is analyzing, speeding and smoothing the transition to sustainable energy worldwide. In doing so, it recognizes that it must bring together the decisions made by policy makers, energy companies, investors and lawmakers.
worldwide, building project teams from all disciplines and all countries. This is the kind of model we are aiming to replicate in our course.

At Miami University a group of faculty from across the institution began to meet to consider a multidisciplinary energy studies program. The goal was to create an interdisciplinary major in energy studies that exposed the student both to the technical and natural science sides of the subject and the non-science side, which is usually social science, oriented but could be extended to humanities, education and fine arts in the spirit of inclusiveness. The goal was to expose students with a particular focus, such as engineering, to the breadth of the issues that encompass energy and to allow them, through that appreciation to better work with others with different knowledge sets to pursue challenges in the board field of energy in a more holistic manner.

The curriculum envisioned in this process involves students entering the major through a gateway course that would introduce them to the energy from a broad range of topics and perspectives. It would also allow students of various interests to work together on energy related issues; bringing to bear their various skills and knowledge sets to complete particular tasks. This class would give students in the major a common foundation of knowledge and vocabulary which would allow them to communicate with each other even as they choose more specialized courses as they continued on. Finally, the major is designed so that students are brought back together for a final capstone experience where they now identify an issue in energy and work towards a solution again in interdisciplinary teams.

As a first step in the realization of this new curriculum initiative it was decided to develop and pilot teach the gateway course. Professors in Geology, Electrical Engineering, Political Science and Economics (the authors of this paper) volunteered to undertake this challenge.

Designing and implementing such a course we want to encourage, if not require students from different discipline to interact and learn from each other. While individual students and faculty may bring a depth of knowledge or interest in their particular area of specialty, the breadth of knowledge created by this interaction facilitates important synergies. Thus we want all students to expand the scope of their knowledge of the issues related to energy while recognizing that they must rely on the depth of understanding of others to full appreciate the issue and its various implications broadly defined.

For example, in the area of oil, students should know the chemical properties of different oils, and why some are more desirable than others; the technical problems with extraction in permafrost or deep in sea beds; the reasons why speculation in energy futures drove the price of oil over $140 a barrel in 2008; or the reasons why economies dependent on oil production are more likely to become petro-dictatorships.

Yet equally important is understanding to whom to turn and how to work with people when this wide, but not necessarily shallow understanding needs depth to fully identify challenges and solutions. Thus, for example our students may all know something about chemical properties of
different oils must also be able to communicate and interact with someone who knows this field well to understand how it might affect energy policy on a national or international level. We want to develop a common knowledge base that will facilitate meaningful collaborative, interdisciplinary interactions across multiple dimensions.

Thus, the goal of the class is to create a common foundation of knowledge in Energy from a natural science/engineering perspective and from a social science/policy perspective, and to have students work together in groups to being to experience the opportunities and challenges of multidisciplinary teamwork in this field.

The remainder of paper is broken down into three additional sections. We first present and discusses the student learning outcomes for the course. The next section focuses on how we presented, and evaluated the students with respect to these outcomes. Following this, we discuss lessons learned and challenges presented in this process. It is important to note as will be discussed in more detail below, that given the small sample (only one offering of the class so far), and it’s developmental nature, we do not have a significant amount data. Thus, a meaningful assessment of outcomes, which would be appropriate at this point in the paper, is unavailable. Finally we will conclude with discussion of the implications of this material on the vision and future of the energy program at our institution.

**Student Learning Outcomes from the Gateway Course**

The specific learning outcomes for our gateway energy class were developed within the more broadly defined learning objectives of Miami University’s Liberal Education classes. These learning outcomes are shown in Table 1.

Our vision presented us with an opportunity to design a course that would address these four broad goals. Institutionally, being able to define our outcomes against these objectives allows us to offer our course as a one that meets certain university-wide graduation requirements, thus increasing its appeal to the student body. By increases students’ potential exposure to the topic we may increase the number of students interested in pursing energy as field of study, and the various engineering, natural and social science disciplines that make it up.
Table 1
Learning Objectives

<table>
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<tr>
<th>Objective</th>
<th>Description</th>
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<tr>
<td>Critical Thinking</td>
<td>Students achieve perspective by combining imagination, intuition, reasoning, and evaluation. Critical thinking develops the ability to construct and discern relationships, analyze arguments, and solve complex problems. Because how we know may be as important as what we know, examining assumptions is an important part of learning. Knowledge of the conceptual frameworks and achievements of the arts, sciences, technology, and the character of global society is crucial to our future.</td>
</tr>
<tr>
<td>Understanding Context</td>
<td>A healthy exchange of different ideas and viewpoints encourages rethinking of accepted perspectives. Therefore, diversity among learners, a supportive atmosphere of group work, active listening, and opportunities to critique results encourage learning through shared efforts.</td>
</tr>
<tr>
<td>Engaging Other Learners</td>
<td>By making thoughtful decisions and examining their consequences, students may enhance personal moral commitment, enrich ethical understanding, and strengthen civic participation.</td>
</tr>
<tr>
<td>Reflecting and Acting</td>
<td></td>
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More broadly, these objectives are ones that our energy group identified as important skills needed of professionals in the energy and energy related fields. While there are still engineers, scientists and policy wonks who sit quietly in their labs and offices thinking deep thoughts, the impact will come from those who can critically approach challenges, work with others and effectively communicate both the nature of that challenge and its potential solutions to a wide group of decision makers. The four objectives listed above underlie that vision. Thus their inclusion as a foundation for the learning objects of our course seemed natural.

The specific learning outcomes for our gateway class are listed in Table 2. As can be seen, the outcomes are broken down into two broad outcomes. The first relates to creating a common foundation of knowledge in energy across a number of important areas. The second set of objectives has students employ this knowledge base, along with their own interests and backgrounds within group settings. The first set of objectives builds develops an individual’s understanding of energy so that he/she may employ it group settings that make up the second set of outcomes.
Table 2  
Gateway Course Learning Outcomes

1) Students are able demonstrate a critical understanding of:
   a. Energy Sources  
   b. The uses of energy  
   c. The effects of energy use  
   d. The public policy of energy

2) Students are able to use this understanding as part of an interdisciplinary team to:
   a. Develop an argument and understand the counter-arguments of an energy related policy issue
   b. Prepare and present both an oral and written presentation on the multidisciplinary facets of an energy related topic.

Thus, Outcome 1 introduces students to where we get our energy, how we use it, how that use affects our world, and us and what sorts of broader policy outcomes this has. These areas while listed separately are not easily divorced from each other and benefit from a co-presentation. Further, the topics are not the particular domain of one discipline or another so each must be presented with multiple perspectives. As will be discussed in more detail below, this material makes up the first half of the course and is conveyed best in a lecture format. Evaluation of students is also done traditionally, with the use of essay exam. It is within this set of outcomes that we are best able to address broad objective 2, understanding context, for it is here that we develop the common core of knowledge that builds the necessary context.

The second set of outcomes is designed to allow students to work together to apply the knowledge they have acquired both in the class and other context to “real world” issues. Each of the sub-outcomes relates to a specific class activity. Again, as will be discussed further below, sub-outcome (a) is addressed within the framework of a formal debate context. Here student teams are given topics, with some on a pro and some on a con side and ask not only to develop arguments that support their side, but be ready to rebut the points of the other side. Further, those students not directly involved in the debate act as the jury, which evaluates the strengths and weaknesses of both sides.

This allows students to employ their developing critical thinking skills, and engage with other learners in both the team and formal debate process. Further, because the topics chosen are not ones that have been the direct focus of lectures used to meet Outcome 1, students are actively learning material through their own research efforts. While the instructors stand ready to direct students in their inquiries, we were not the sole source of information.
The final learning outcome is achieved by a group research project that has as its outputs both an in class presentation and a written report. As with the debate the group nature allows students to engage with other learners and demonstrate critical thinking in the preparation of both deliverables. Project topics are created by the instructors but augmented by suggested topics by the students. Each group has time to consider the several topics and asked to rank them in order of preference. The instructors then assign topics. Most, but not all topics are multi-dimensional policy topics that again allow students to bring their joint and several interests and strengths to bear. Instructors monitor progress of projects both by requiring a project proposal and regular progress reports, and by requiring “dry runs” of project presentation with critical feedback that became part of the evaluation process (Did students adapt their presentation to the given comments or did they choose to ignore them?).

As with the formal debate, peer evaluation is a part of the process. Each group evaluates the others’ presentations as well as within group peer evaluations on input and team work. Further, material from the presentations is used in the final examination for the class which has at least one essay asking students to compare and contrast information from a number of presentations across a number of different dimensions. The goal is to be sure that even when students are not presenting their own material they are engaged in the efforts of the other learners. Thus, even the evaluation process becomes a learning opportunity for the students.

Having now outlined our goals on how we expected the students to manifest their mastery of material, we turn to the nature of the material presented.

**The Course Content**

In this section we will outline both the material cover in the gateway course. The full course syllabus with a detailed calendar of topics is available in the appendix and is available from the authors upon request. Class material was broken down to line up with the learning outcomes discussed above. In this way the class followed from one outcome to another always building on the material and skills presented before. We also include a short section on how instructors evaluated student performance.

**Learning Outcome 1: Showing Critical Understanding**

The material that was used to create the informational base in learning outcome 1 was broken up into four main contexts: Economic, Scientific, Engineering and; Public Policy. A sampling of the material that is covered these contextual subjects are found in Table 3a through 3d. It is important to note that these were not presented in strict functional flow, such as all the Engineering material followed by the Economic material. Instead, the presentation integrated with the organizing principle being the energy source and use. Thus, for example we might present renewable resources, starting with the engineering aspects, moving on to the issues of
economic and environmental sustainability of renewable energy, and then discussing the public policy issues that exist currently and into the future.

**Table 3a**
Economic Context

*The students learn the basic economics, resources sustainability, the business of oil and the automotive industry. The topics are broken down as:*

- Understanding sustainability—neoclassical and ecological approach
- Sustainability of resources
- The economics and business of oil
- The rise of the automobile industry
- Sustainable energy and business case

**Table 3b**
Science Context

*The students learn the formation and chemical compositions of fossil fuel, the emission problem of burning the fossil fuel. The topics include:*

- Geological frameworks of fossil fuel
- Wave and tidal energy
- The economics and business of oil
- Geothermal energy

**Table 3c**
Engineering Context

*The students study power producing systems using fossil and renewable energy sources. The components and operations of nuclear reactor, solar panel, wind turbine, and bioreactor are investigated. The topics are:*

- Energy sources and consumption
- Environmental impact of energy uses
- Thermal power generation
- Solar power generation
- Hydro power generation
- Wind power generation
- Nuclear power generation
- Alternative transportation energy technologies
The topics of investigation include the politics of oil, the impact of the oil production and consumption on the producing and the consuming states, the carbon taxation issue and the international efforts in limiting the greenhouse gas emission. In particular:

- Where we are and how we get there with respect to fossil fuel utilization
- Oil—the political and economic context
- Energy future issue
- RPS (renewable portfolio standards)
- Carbon cap and trade issue
- International climate conferences and agreements

As noted above, the class utilized a number of formats to deliver course material to the students. The materials above were presented primarily as lecture. There are readings for students to prepare for class and occasionally, as when talking about the electric car, videos. PowerPoint slides when used were available to the students before lectures and they were expected to have familiarized themselves with the material and be prepared to ask questions and discuss the material.

This is, in many ways, the least preferred method to engage students in the material, however it is necessary. As we want all students to have this basic foundation of knowledge it is important that we make sure it is communicated to them in a consistent manner that insures this goal. As it is anticipated that this foundation of information will be used as they continue on in the energy program we need to be sure that students hear, process and are able to use the material.

A significant, non-lecture-based learning experience in this portion of the class is the field trip to the University’s on-campus steam plant. The plant, which provides steam for the University’s campus heating system also generates some of the electricity need on campus. It affords the students the opportunity to see a working gas-fired electricity generation plant only a short walk across campus.

Once students have been presented with the above material the focus of the class changes to one that more actively engages them with each other.

Learning Outcome 2a: Team Debates
As discussed briefly above, team debates are set up as a formal forensic style debate. Teams were given either the affirmative or the negative to one of the two following topics:

I. Resolved that climate change is occurring but not man-made
II. Resolved that since the industrialized world created climate change they should be responsible for its amelioration.
Teams are given significant time to research both their side of the resolution and to prepare to rebut the other side. They are required to seek source material outside of lectures presented in class; again to stimulate active learning. In at least one class period faculty are available to help teams with their material and guide them towards further material.

In the actual debate member of each team delivers a prepared time-limited opening statement in support of their side. After this a member of each team was given time to prepare a rebuttal to the other teams opening. Following rebuttals is a question and answer phase where each team member asks the other side questions on the resolution. The Jury that is made up of all the students who are not debating that day also poses the questions. Finally each team is given a set time for a closing statement.

After the debate the jury is asked to vote for which side they considered to be the winner and to write a short statement justifying their vote. Instructors collect the votes and justifications and mark the students based on the strength of arguments, ability to answer questions and the jury

Learning Outcome 2b: Group Projects

Early in the term groups of four or five students are created by the instructors. The groups are mixed according to their majors so that each team is made up of a variety of students with different academic interests. Each group works with faculty to develop a project highlighting a particular area of energy issue that has both a significant engineering/natural science aspect and a significant policy aspect.

Groups are asked to submit their preferences over a set of predetermined topics questions. Topics used in the lasts class teaching are shown in Table 4 below. As can be seen in all cases the topics are phrased as policy questions, most but not all at the federal level. Students are told that they should consider their group to be, in essence, a lobbying firm preparing their position paper and making a presentation before a group of policy makers who are considering their question.

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<td>Sample Project Topics</td>
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<td>➢ Should the U.S. government have the sole authority to regulate the site selection and building of wind farm?</td>
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<tr>
<td>➢ Should there be a tax on those American citizens with a high carbon footprint?</td>
</tr>
<tr>
<td>➢ Should the corn-based ethanol industry continue to enjoy the high level of subsidy?</td>
</tr>
<tr>
<td>➢ Should the U.S. government encourage the nuclear power generation?</td>
</tr>
<tr>
<td>➢ Should the U.S. government institute a minimum gasoline price?</td>
</tr>
<tr>
<td>➢ Should the U.S. government encourage extraction of all domestic fossil fuels?</td>
</tr>
<tr>
<td>➢ Should the U.S. government encourage clean coal technology?</td>
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As early guidance, groups are given certain mandatory elements for their project regardless of the topic. Each is told that their report and presentation must be clearly focused on energy, and centered on a policy expectation. Further, the deliverables need to have focused on the U.S. or the U.S. Governments (federal, state and/or local), and be forward looking with policy prescriptions looking to what should happen in the future. Finally, in keeping with the interdisciplinary nature of the class, the project needed to include engineering, science, economics and policy elements. As will be discussed below, these elements form the basis of groups’ evaluation on this project.

As mentioned, one element of the project was a 30-minute oral presentation of the groups’ finds to the class. Again, this activity was seen as an important way to engage the students, and to help them to experience a what may be an important skill when they have gotten jobs – communicating their finds to a group. We also feel that the information that is presented by each group can be a significant learning experience for the other students. Topics are picked because they were timely, and important and there would not be time for the instructors to adequately cover the material. Thus, students were instructing each other with these presentations.

Students are required to present a dry-run presentation before presenting before the class. The idea here is to give groups input on how to improve their presentation and make it a unified effort instead of the all too often four individuals giving four presentations (the oral equivalent of the group paper that is four individual papers with a staple through them). As this was the first time that instructors often see the material developed by the student for the project, there is often also input as to the content and focus of the project; being sure it meets the requirements and answers the question posed.

Final presentations made in-class before instructors and faculty are made two weeks later so that groups have time to incorporate the dry run comments. Each group thus far has prepared power point slides as part of their presentation (not a requirement) that are subsequently made available to the entire class through the online classroom management system (Blackboard). At the end of the presentation is a short (10 minute) question and answer session opened to everyone. We were pleased at how lively this could be given what seemed like a slow start of this type of student involvement early in the class.

The final report paper is submitted by the final week of class. The expectation is that students each contribute 7 to 10 pages each making for a 40-page paper in total. As noted above, it is stressed that the report should be written as a single cohesive document and not four papers with an introduction and conclusion tacked on. As may be clear to many, this is one of the most difficult points for students to learn and we try to emphasis it with greater or lessor success.
As we turn now to evaluation, it should be noted that group presentations is a significant portion of the written final examination for the class. Again, our goal is to keep students engaged with presentations even as they are not themselves actively presenting.

**Instructor Evaluation of Students**

Students are evaluated in a number of ways: Examinations of various types; participation as members of group projects and debate teams; peer evaluation of participation in same. All of these form the basis for the students’ final semester grade in the class.

The class, as currently structured has three examinations of which have various weights on the final grade, and which increase through the semester. The first examination is an on-line multiple-choice test. Students are given a weekend to go online and take a 40 question exam over material to that point. This choice was made to maximize in-class activity time as the evaluation is done at the students’ convenience outside of regular class.

The second examination is a take home essay exam. Students are given a set of questions of which they must choose a sub-set and write a well-structured essay in response. Students are given the questions and told that a week hence their answers are due. In this case we use TURNITIN, an online grading program that also checks for plagiarism. Each instructor submitted two questions and is responsible for grading those questions.

The Final examination is also essay but in this case completed in class. Students are again given questions in advance of the final exam time. Here, as the questions require a synthesis of information from across the semester, it is felt that students should have time to prepare their responses. As noted, many of the questions require that the student draw information from multiple group project presentations. In this case each instructor reads each exam and grades are assigned as an average across these multiple evaluations.

As will be discussed in more detail below in the lessons section, it is in the course evaluation portion that we have faced the greatest challenges and where much of the revision in the class will be focused. Students simply did not have a good understanding of by whom and how they were being graded, leading to frustration on all sides.

**Evaluation and Assessment of Learning Outcomes and Objectives**

As of this writing, the class has been taught once. Thus we have limited data with which to evaluate and assess our success at meeting our outcomes and objectives. Further, when we did employ assessment tools, our focus was not primarily focused on these but on the structure of the class using the more general institutional evaluation tools. Thus time, and our own focus have conspired to give us too little insight in this important area.
Our major evaluation tool was the standard end of semester instructor evaluation with a number of additional questions specific to the course. The student feedback is generally positive, and it indicates the accomplishment of some of our objectives.

On learning objective attainment it suggest that students have gained significant awareness of the nation’s energy policy. Further, it we have indications that students realize how the environment, technology and economics affect the politics, and why it is so difficult for the nation to get off the fossil fuel dependence, especially the imported oil. Above all, students’ comments both in the evaluation and to faculty indicate that the course stimulates the student interest and passion for the national need to revamp the energy policy.

In terms of our objective to create engaged students acting with others, our group and team projects seem to have been successful and seen as by students as positive learning experiences. This is not to say that these were universally positive experience as anyone who has employed such activities in a class is all too well aware. Students who had group members who were in groups or teams that had members who did not put in the necessary time (slacking or free-riding) where frustrated by the process. Interestingly however most, while pointing out slacking members to instructors, often chose not to penalize those members significantly in peer evaluation.

It was also clear those unforeseen aspects that always exist in a first incarnation of a class colored students’ evaluation and assessment of the class. In particular, having four instructors with no clear “point person” created frustration especially around grading, which was often done individually and then aggregated. Thus, negative comments were plentiful and not based on course content or other material but with frustration over grading. As will be discussed below, this is an important area that needs careful consideration in the next offering of the class.

Also, as will be discussed below is the importance of building into the class a more careful mapping of evaluation and assessment mechanisms back to the learning outcomes and learning objectives of the class. The lack of data in this area is not overt, but an artifact of not understanding what were the important questions to ask, and how to ask them that will give us the data we need for a meaningful evaluation and assessment.

**Lessons and challenges**

Thus, one of the most important lessons to come from our experience with the teaching of this class is the importance of careful consideration of how do design a course from the ground up with a goal not only of creating a high quality learning experience for the students, but to do so with an eye towards the goal of meaningful assessment. As it turns out, the class is reasonably well planned out in terms of leaning objectives and outcomes that feed into and support those objectives. Our challenge into the future is to more carefully document and asses this process.
Fortunately a number of institutional resources exist and to which we have access to address this important goal. In essences what is a serious shortcoming currently is easy to address.

Another series of lessons learned and challenges identified come from the nature of the institution that is higher education. An important strength of this course is its interdisciplinary nature. Students are able to come together with students not in their major, or even academic center. Engineers must work with business students, Business students and must work with social science students, and they all must learn a common language and way to approach problems.

In its current incarnation this is also true of the faculty that teach the class. In our first offering of the class, four faculties came from four different departments and three different divisions. Such collaboration is rare and often fraught with the conflict of differing teaching styles, student expectations and cultures. As the students learn to work together so do the instructors; an exciting opportunity.

In many forums it is just such collaboration and seen as the evolutionary path of higher education in the US to provide the broad array of ideas students need to have exposure to in the growing global economy, a single emphasis such as a disciplinary major may not be ideal. Instead new major such as Energy which brings together the wisdom and learning of many disparate fields to create the broad understanding needed to address growing challenges. As noted, this gateway course is the introduction to such a field and is designed to compliment a traditional major by giving students the opportunity to work with other who have different skills but similar broad interests.

However, it is this strength that creates some of the largest hurdles. Our University like most is organized by discipline and not by broad focus. Thus the engineers are grouped with the engineers and the geologists are with the geologist and so on. These silos are fundamental to the structure of the institution and how resources and time are allocated. Thus, there is no predisposition to or good mechanism for this type of cross silo effort. This is not to say that it isn’t encouraged. Administrators see the benefits of interdisciplinary work both in terms of research and curricula, but they aren’t sure how to fund, evaluate or reward it.

Further, in the current climate of shrinking resources, the status quo in terms of silo organization has become fortified. The course described herein was taught by the four faculties as a gratis adds on to their normal teaching load. Each department chair and dean noted that the class was important but was unwilling or unable to allow their faculty member to teach the class as part of their regular teaching load. Each was expected to teach in their department to cover the courses that needed to be covered there. This should not be taken as a faulting of any of these administrators. Each must be sure that the commitments we have made to students pursuing existing degree paths are met. However it leaves little room to consider expansion of what we do.
This is not to say that there is no support for this effort across campuses. One division has been willing to donate space for an Energy Center that would be used in the creation of the program of which this course is the gateway. The President of the University has publicly pointed to the program as a model of the type of interdisciplinary effort that is a key to the evolution of the institution. However no one, including the President is willing or able to provide the fiscal resources necessary. We have been encouraged to teach the class again and continue to develop an energy curriculum but there is no support to offset our loss to this program in our current teaching responsibilities. We are encouraged to seek outside funding.

Higher education is typically organized around disciplines, colleges and divisions. Working within them can sometimes be challenging, but working across them provides hurdles of major proportion. In developing and teaching this energy course, we have succeeded, to a certain extent, in bridging this discipline barrier.

The enrolled students include engineering, science, business, humanity, political science majors. The followings are a list of lessons and challenges we learned in developing and teaching the course.

Thus, we must find a way to make a program that at its heart is about sustainability and shrinking resource bases, sustainable in an environment of shrinking resources.

**Conclusion: Looking Towards the Future**

We have developed a broadly multidisciplinary educational approach to respond to the needs of students in solving energy problems. In this gateway course, the first step towards a larger energy curriculum, students are engaged with others across disciplines. This interaction serves to enhance peer-to-peer education and build knowledge among student cohorts. The group projects and team debates enhance students’ knowledge and obliges them to analyze problems from multidisciplinary perspectives.

As in any initial effort of this kind the experience was as much a learning experience for the faculty as the students. While the students learn about energy production, use and policy, we learned about teaching such a multidisciplinary class. Some of these lessons can be easily transferred into the next iteration of the class. This is especially true of the way that students were evaluated. We must be more centralized, focused and transparent in this regard. While one person need not do all the grading, one person needs to be the students’ point of contact for grades and the mouth piece for expectations in terms of what is expected especially in terms of what constitutes a “good” answer on an exam.

Other lessons will be more challenging to incorporate. For example, we are very pleased with the model that provides the insight from four faculty approaching energy from four different perspectives. Yet this commitment of resources to one class underlies the scarce resource issue
discussed above. It is likely that a future version of this class would rely on a single faculty member who coordinates other faculty from across campus who come in and address specific topics. Thus, instead of having an Electrical Engineer in the room each class he may be there only on the days that such information is presented. It reduces much of the interesting and spontaneous discourse that occurred having various field represented regularly, but such tradeoffs may be necessary to assure the continued offering of such a class.

The students seemed to have benefited from the format; they seemed to grow in their understanding of the complexity of the issues involved in energy. Non-science students seemed especially to grow as they learned of the limits put on policy by the reality of the creation and distribution of energy in its various forms. Further, it was obvious that engineering and science students realized that the days of science happening exclusive of policy are over, if they ever really existed. All seemed to grow in the understanding that no one discipline has The Answer to our energy concerns and that if we are to move to a sustainable energy future it will take teams such as they were involved in that will points us in the direction to get there.

Reference