AC 2009-945: AN INTRODUCTION TO ENERGY CHOICES: A MULTIDISCIPLINARY APPROACH

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An Introduction to Energy Choices: A Multidisciplinary Approach

Abstract

The Indian Affairs Office of Indian Energy and Economic Development (IEED) was established to assist in economic development on Indian lands, in part by assisting development of workforce capacity through education and facilitating partnerships between tribes and the private sector. Colorado School of Mines received a grant from IEED to develop an energy engineering program of study to be used by Tribal Colleges. After discussing the program with the leaders from two tribal college test locations, a curriculum was created. The test locations were chosen because of their geographic diversity and their technical thrust. The curriculum presently consists of six courses: Introduction to College Mathematics and Science (a systems course), Topographic Surveying, Introduction to Engineering, Design of a Wind Farm, Solar Design, and an Overview of Energy Resources. A key course in the curriculum is a review of energy resources. This course provides an overview of both traditional as well as alternative energy resources. A life-cycle approach is used to investigate each energy resource: oil and gas, coal, hydro, geothermal, nuclear, solar, wind, biomass, and synthetic fuels. The course is designed to inform and prepare students who could enter energy fields as engineers. Colorado School of Mines is responsible for preparing the curriculum at the lecture level and for training the college staff through a summer workshop to offer the courses. We are also available during the academic year as content consultants as well as visitors to present special topics to the college students. The process of curriculum development has resulted in challenges as well as successes. This paper will describe the overall IEED project and, specifically, the Overview of Energy Resources course, discuss the assessment of both the teachers and the students participating in the course, and will detail the challenges and successes of the program.

The Cooperating Elements

With funding through the United States Department of the Interior Office of Indian Energy and Economic Development, faculty from Colorado School of Mines have developed an energy curriculum to be used by Native American Tribal Colleges. Faculty from two colleges, Navajo Technical College and United Tribes Technical College, have been trained to teach the curriculum and have offered selected modules to their students.

Colorado School of Mines

Colorado School of Mines, founded in 1874, is a public research university devoted to engineering and applied science[1]. With a current student body of about 4200, it has the highest admissions standards of any university in our state and among the highest of any public university in the U.S. Colorado School of Mines has distinguished itself by developing a curriculum and research program that is geared towards responsible stewardship of the earth and its resources. In addition to strong education and research programs in traditional fields of science and engineering, Colorado School of Mines is one of a very few institutions in the world having broad expertise in resource exploration, extraction, production and utilization. As such, Colorado School of Mines occupies a unique position among the world's institutions of higher education . Colorado School of Mines is involved in a wide spectrum of energy research

including fossil resource exploration, extraction and processing; renewable energy production and distribution; and environmental impact and remediation[2].

The IEED Program

The U.S. Department of the Interior's Office of Indian Energy and Economic Development (IEED), includes a Division of Economic Development (DED) charged with fostering strong sustainable reservation economies through management of economic programs, conferences, workshops, and grants[3]. DED strengthens tribal business infrastructures by facilitating the transfer of information and technology to tribes. Through this division, the IEED has funded the Colorado School of Mines to develop a curriculum that can be used at Tribal Colleges. The curriculum is designed to allow students to prepare for careers in the energy industry and/or build expertise in managing and developing energy and mineral resources that would be available to their respective tribes. The developed curriculum is to be presented to faculty at Tribal Colleges, Colorado School of Mines faculty will be available to team-teach some portions of the curriculum, and Colorado School of Mines faculty will serve as a source of technical expertise for the Tribal Colleges. The Navajo Technical College in Crownpoint, New Mexico, and the United Tribes Technical College in Bismarck, North Dakota, were chosen by IEED as the prototype testing locations.

United Tribes Technical College

Located in Bismarck, North Dakota, United Tribes Technical College[4] serves to provide a two-year college education to the Native American people in the region. For over 39 years, UTTC has served over ten thousand American Indian students from more than 75 federally recognized Indian Tribes across the nation. In addition to American Indians, the college welcomes and serves students of all backgrounds. There are approximately 900 students currently enrolled at UTTC. Considered a 1994 Tribal Land Grant Institution, the College was founded to provide a community in which Indian people can acquire an education and obtain employment. UTTC is operated by the following five tribes: Three Affiliated Tribes of Fort Berthold, the Spirit Lake Tribe, the Sisseton-Wahpeton Oyate, the Standing Rock Sioux Tribe, and the Turtle Mountain Band of Chippewa Indians.

Navajo Technical College

Serving about 350 students, Navajo Technical College is located in Crownpoint, New Mexico. In 1979, the college began as the Navajo Skills Center. Associate degrees were offered by 1985 with the goal of working toward programs that would bolster the science, technology, engineering, and math competitive needs of the 21st century. Navajo Technical College serves the Navajo Nation which has a population of almost a quarter million people in a geographic region extending into three states[5].

The Overall Energy Curriculum

The original concept was to create one comprehensive course; however, through discussion with the administration and teaching staff from the Native American Tribal Colleges, it was determined that a single course would not adequately address the Tribal Colleges' needs. In response, a *series* of courses was developed to aid Native American Tribal Colleges in their

offerings in energy education. A review of energy curricula in North American colleges and universities revealed many models. At the two-year college and certification level energy programs were closely looked into because of the similarity with the two-year time frame in the Tribal Colleges. Examples include New Hampshire Community Technical College, Lawrence Technological University and Lansing Community College, and Lane Community College[6,7,8] . Undergraduate multidisciplinary majors and minors offered at University of California at Berkeley, Humboldt State University, University of Ontario Institute of Technology, and Sonoma State University[9,10,11,12] were investigated. Although more advanced than our needs, graduate programs such as that at Wayne State University[7] were also surveyed. Many of these programs offered technician certification or emphasized alternative energy. In response to the tribal college desires, we designed a six-course curriculum with coverage of both alternative and traditional energy sources as well as skill sets (general mathematics, general science, and topographic surveying) that the unique set of tribal students need.

The first course requested by the Tribal colleges was a land surveying course, as there was an immediate need for mapping of tribal lands and resources and such a course would facilitate local employment. The lessons were developed during the 2006-7 academic year and a faculty workshop was offered in the Summer of 2007. Portions of this course are presently being integrated into existing mathematics and science classes. This model of training the faculty to offer the courses at their individual colleges continued for each of the successive courses.

The tribal colleges next requested a "bridging course" to help high school seniors and first-year college students strengthen their mathematics and science skills in order to better prepare them for more intense energy curricula. The need for this grew out of a concern that many students entering tribal colleges were ill-prepared to undertake energy/engineering related classes. After course development, the faculty workshop was presented in the Summer of 2008. Modules from this class are successfully being used in both high schools and colleges in tribal communities.

Because of the availability of wind and solar resources on tribal lands, two classes specializing in these topics have been created. The "Wind Energy" faculty workshop was offered in the Summer of 2008 while the "Solar Energy" workshop will be held in the Summer of 2009. Also, in the Summer of 2009, a workshop on the "Energy Resources" course will be offered. The final capstone course in Engineering Design for Energy will be presented in Summer 2010. The development and offering of the courses of the energy curriculum have been scheduled to meet the needs of the tribal colleges, however, as a "packaged curriculum," the order of offering would be quite different. Table I illustrates the curriculum for an energy program with the courses arranged in the order that would be appropriate for a two-year college. Key to this curriculum is the Energy Resources course and the development of it will be presented in this paper.

Semester	Course	
I	Bridging Math and Science	
II	Land Surveying	Energy Resources
III	Wind Power	Solar Energy
IV	Introduction to Engineering	

TABLE 1
ENERGY CURRICULUM FOR A TWO-YEAR COLLEGE

Energy Resources Course

Understanding the resources that are present on Native American Lands will help tribal communities to better plan the use and exploitation of these resources. The Energy Resources class is designed to present a balanced view of traditional and alternative energy sources. The for each energy resource, a life-cycle analysis approach has been designed. The sources are:

- Oil and Gas
- Coal
- Nuclear
- Hydroelectric
- Geothermal
- Solar
- Wind
- Biomass
- Synthetic Fuels
- Fuel Cells

The life-cycle analysis will address the topics:

- Geologic or geographic occurrence
- Cost of extraction
- Efficiency in conversion to power
- Environmental impacts and concerns
- Cost of power production
- Present capacity
- Future capacity predictions
- Decommissioning

The course is designed for students in their first or second year of college. The prerequisites are high school mathematics and science proficiency. Specifically, students should be able manipulate numbers and solve algebraic equations. Also, they should be able to covert units and apply dimensional analysis. In the areas of science, they should be able to classify rocks, define kinetic and potential energy, and explain how a generator creates electricity.

To prepare instructors at Tribal Colleges, a workshop will be held to introduce the curriculum. Table II describes the syllabus for the one-week training workshop for educators. The workshop participants will be given a notebook of lesson plans and hands-on activities for each energy resource. The workshop introduces the categories of activities through a model. For example, a mapping exercise is introduced in the oil and gas section. This same exercise can be used for other energy resources, as well. Another example is cost analysis which can be applied for every topic. The capstone event is a "Great Energy Debate". Participants will be assigned an energy resource and will argue that their resource is the "best". However, the participants must support their arguments with data.

Day	Morning Lecture	Morning Activity	Afternoon Lecture	Afternoon Activity
1	Definition of Energy, World Wide Energy Usage, Power Production	Measure efficiency rates of energy conversion	Oil and Gas	Map resource locations
2	Coal	Cost analysis for lighting a classroom	Nuclear	Comparison volume of Coal, Oil and Gas, and Uranium for energy content
3	Hydroelectric	Kinetic and potential energy experiment	Geothermal	Map resources according to temperature and energy capacity
4	Solar	Measure energy from sun	Wind	Construct a small windmill generator; investigate role of blade angle
5	Biomass	Garbage/Energy Calculations; Gas production from Garbage	Synthetic Fuels and Fuel Cells	The Great Energy Debate: Classroom Capstone Activity

TABLE 2
ENERGY WORKSHOP SCHEDULE

After participating in the summer workshop, seven instructors from NTC and from UTTC will take the material presented and teach is at their respective schools. Some will use modules from

the summer workshop, some will use hands-on activities as examples for their already-existing courses, and some will offer the Energy Resources Course as a total class.

Assessment

Both formative and summative assessments have occurred for each of the previous workshops. Formative evaluation supports the on-going improvement of the implementation of the workshop while the summative portion examines the extent to which the goal of training the participants to lead a future class has been reached. The formative evaluation included daily workshop reflections and a debriefing session. At the end of each day of the summer workshops, the teachers were asked to discuss to the following questions: 1) What have you learned in today's workshop? 2) What questions do you have concerning the content that was presented? and 3) Is there any information that was discussed that you would like to know more about? The teachers' responses to these questions were used to prepare the next days' activities. An anonymous Keep/Quit/Start survey using 3x5 card was employed twice during the week, as well. For the summative evaluations, participant questionnaires and pretest/posttest results have been used. For the previous workshops, the pretest/posttest results have indicated an increase in content knowledge and the participant questionnaires have particularly expressed satisfaction in the hands-on activities. Because of this, the energy resource class continues to contain a large number of hands-on activities. Identical evaluation techniques will be applied to the Energy Resource Workshop offering and results will be available by June, 2009 at the ASEE meeting.

Challenges

As the project progressed, there have been many “lessons learned”. The primary lesson has been to listen to the users (the tribal college leaders and instructors) and meet their needs. They are specific about the courses that they need and about the pedagogy that works for their students. For example, they expressed concern that students were not well prepared in Mathematics and in Science. Therefore we created the Bridging Course. They also explained that the tribal college students do not do well in a lecture format and are better learners with hands-on activities. We had a pre-conceived notion of what an energy curriculum would look like, but this has been revised. We began with one condensed course. This has been expanded to a six-semester sequence. Topographic surveying would not have been on our list of topics, but it is very important to those on Native lands and a first step in understanding what energy resources might be available. The college leaders also wanted both an overview of energy course as well as specific courses on wind and power, two possible resources at their locations. Finally, although their goals are to use the six classes for an energy major or minor at their schools, practically, they cannot absorb more than one or two new classes per year. Hiring additional instructors is difficult so the courses must be taught by existing faculty. Many times, modules or lessons have been excerpted from the curriculum we have presented and used in already existing classes. Again, listening to the users has been key in developing the classes in modular fashion and in presenting them as workshops to the instructors.

Bibliography

1. www.mines.edu, accessed 10/08.
2. Colorado School of Mines,” Energy and the Earth: Research 2008”, http://inside.mines.edu/researchmag/energy/energy.pdf, accessed 10/08
3. http://www.doi.gov/ocl/2006/DiversifyingNativeEconomics_091907, accessed 10/08
4. www.uttc.edu , accessed 10/08
5. www.navajotech.edu, accessed 10/08
6. www.lrcc.edu , accessed 11/08

7. www.nextgenergy.org/industryservices/curriculum_development.asp , accessed 11/08
8. www.lanecc.edu/instadv/catalog/science/programs/energy.htm , accessed 11/08
9. http://erg.berkeley.edu/index.shtml , accessed 11/08
10. www.humboldt.edu/~ere_dept/academics/energy_descr.html , accessed 11/08
11. www.engineering.uoit.ca/programs/energy_systems_engineering.php , accessed 11/08
12. www.sonoma.edu/ensp/ , accessed 11/08