AC 2008-392: READING, WRITING - ENERGY: AN NSF CCLI PROJECT TO ENHANCE A FRESHMAN CORE CURRICULUM NATURAL SCIENCE COURSE

Christine Ehlig-Economides, Texas A&M University

Christine Ehlig-Economides is a full professor of Petroleum Engineering at Texas A&M University. She worked for 20 years for Schlumberger in the oil industry in more than 30 countries. Dr. Ehlig-Economides has a B.A. in Math-Science from Rice University, an M.S. in Chemical Engineering from the University of Kansas, and a Ph.D. from Stanford University in Petroleum Engineering. She is currently developing education and research programs in energy sustainability. She was elected to the National Academy of Engineering in 2003.

Cathy Mariotti Ezrailson, University of South Dakota

Cathy Mariotti Ezrailson is an Assistant Professor of Science Education at the University of South Dakota. She received her B.S. in Geology and Comp. Science and Ashland University, her M.S. in Curriculum & Instruction: Science Education from the University of Houston. She received her Ph.D. in Curriculum & Instruction: Physics Education from Texas A&M University. Her specialty is in the development of interactive science curriculum models based on project/problem-based engineering design methods for K-12 and postsecondary levels. She is a former PAEMST Award winner for Texas and a TAMU MALRC Fellow.

Ramesh Talreja, Texas A&M University

Ramesh Talreja is a professor of Aerospace Engineering at Texas A&M University. He has taught for 30 years in various disciplines of materials engineering, mechanical engineering and aerospace engineering in Europe and in United States and has lectured extensively around the world. Dr. Talreja has a Bachelor's degree in Civil Engineering from University of Bombay, a MS degree in Structural Engineering from Northeastern University, and PhD and DTechSci degrees from the Technical University of Denmark. His technical expertise lies in composite materials and he is currently engaged in educational and research activities in sustainability.

Reading, Writing - Energy: An NSF CCLI Project to Enhance a Freshman Core Curriculum Natural Science Course

Abstract

ENGR 101 is a natural science core curriculum course offered every semester to non-engineering majors at a Research-I university in Texas. With particular emphasis on energy and its sustainability, this course aims at helping students develop critical thinking and effective communication skills to become responsible and scientifically literate citizens. Unique elements in the course design include the student population it targets, the skills and knowledge it emphasizes, and the varied conduct of the class meetings.

A key learning design characteristic is the variety of learning strategies employed, including

- weekly quizzes on assigned reading,
- interactive lectures provided to all students as a group,
- weekly recitation sessions of no more than 20 students designed to engage students in interactive discussions of current energy news and how it impacts energy sustainability,
- weekly essay assignments requiring students to summarize, analyze, and synthesize material they are initially provided, and later encouraged to find for themselves, and
- student-centered semester-long projects with open-ended guidelines.

The diverse instructional team includes two full professors in charge of the lectures, a third full professor managing the recitations, and graduate teaching assistants (GTAs) and undergraduate peer teachers (UPTs) who conduct the recitation sessions. While the full professors all come from engineering disciplines, UPTs are selected from students who have previously taken the course, and both GTAs and UPTs can come from any of the university degree programs.

The ENGR 101 course was piloted for the first 2 semesters only to honors sections. NSF CCLI funding for the Reading, Writing – Energy (RW-E) project is providing a mechanism to enhance the course as enrollment is opened to both honors and regular students. Students selected from those who took the course in the initial honors offerings have subsequently become UPTs for the recitation sections.

The RW-E project funding includes support for an assistant professor and a PhD level graduate student from the College of Education and Human Resources. These two project participants have drafted a training program for the UPTs and GTAs to be held prior to each semester, and they convene the instructional team on a weekly basis to share experiences, share additional learning resources and discuss plans for the following week. They assist the engineering professors in charge of the course to incorporate student-centered learning strategies in line with design principles of the *How People Learn* [1] framework. They also conduct research on the course design and its effectiveness in achieving learning goals, emphasizing critical thinking, effective communication skills, learning from peers, and issues awareness.

The RW-E project is highly beneficial to development of the ENGR 101 course. Involving learning scientists in the course design and planning has greatly enhanced its value to students.

Introduction

The rationale for ENGR101 is to create a course that brings the knowledge about energy and its impact on the society to general students without requiring engineering background. The course is a product of engineering knowledge, packaged in a way that it can be digested by non-engineers. The course is designed to achieve the following key learning outcomes:

- energy content knowledge (energy resources, utilization, and importance to society)
- sustainability concept understanding (environment, economics, society)
- energy awareness (news, scholarly journals, policy, geopolitics)

while improving skills in oral and written communication and critical thinking.

The original planning team for ENGR 101 included representatives from the colleges of engineering, science, education and human resources, liberal arts, agriculture and life sciences, and architecture. The reason for so much interest in the course may have been partly because it is so unusual at our university for the college of engineering to offer a course intended for all students including non-science and non-engineering majors. Very prominent faculty attended early meetings about what the course might try to cover and how. Especially, learning scientists and representatives from the university Center for Teaching Excellence were ready participants in planning this course.

After about one year, the course was proposed for approval as a 4-credit hour core curriculum natural science elective, which was granted in spring of 2006. The course includes three 50-minute lectures each week provided to all students taking the course. In addition, each student is enrolled in a weekly 2-hour recitation section limited to 20 students.

The course was taught for one semester on a trial basis and became a catalog offering in fall 2006. The course was offered first only to honors students for the spring and fall semesters in 2006 because the intent was to try out certain ideas on the learning process and to develop future undergraduate peer teachers (UPTs) who would teach the recitation sections for regular students when they reach upper class level. The idea to use UPTs is inspired by the work by Brian P. Coppola through his Cognitive Apprenticeship Model (CCAM) patterned, in part after the one proposed by Collins, Brown and Neuman.[2,3] In particular, honors students showing particular capability in the recitation section were asked whether they might be interested to teach a recitation section to regular students at some later time. This has produced a list of UPTs becoming eligible to assist with the course.

The possibility of applying for NSF CCLI funding was first considered in 2005 before the course had been approved by the university. The original CCLI proposal emphasized a pilot program for the Energy Engineering Certificate program that was to be proposed with the ENGR 101 course as the only required course for the program. Although some of the NSF reviews were favorable, others betrayed perhaps somewhat justified doubts whether the proposal was premature. One year later the proposal titled Reading, Writing – Energy (RW-E) was submitted with an emphasis on only developing the ENGR 101 course. This proposal embodied some ideas in the original proposal, but many new ideas were put forward as well. By that time the course had been offered to honors students for one semester.

The impact of CCLI on this course cannot be overstated. Preparing the proposal forced the PIs to think carefully what they hoped to accomplish in ENGR 101 and how to get there. The actual funding has provided this effort with the continued involvement of learning scientists who put an invaluable imprint on the approaches being taken. The professors for ENGR 101 are all

engineers, but this course is taught in a very different way from the usual engineering courses. By now the course has been taught to 4 honors sections and 3 sections with regular students. This paper describes how the course has been enhanced by the learning scientists who have greatly helped the engineering professors, the graduate teaching assistants (GTAs), and the UPTs who now understand better how learning occurs and their role in that process.

The research program spawned by the RW-E project is described in a separate paper. This paper will first describe the evolution of the ENGR 101 course from how it started to how it is conducted today and will then describe the impact of the CCLI project on this process.

ENGR 101 Energy: Resources, Utilization, and Importance to Society

Each week in the ENGR 101 course students attend 3 lectures as a group and participate in the 2-hour recitation in smaller sections. The lecture topics are listed by week in Tables 1-3. Students have a reading assignment each week related to the material to be covered in lecture, and there is a quiz at the start of the first lecture of the week on the reading assignment for that week. There is a reading guide provided for each reading assignment, and the quiz is designed to cover what is emphasized in the reading guide. The rationale for the weekly quizzes is to ensure that students read the material because both recitation and lecture rely on some content knowledge in order to be meaningful.

The recitation is intended to engage students in discussions. Recitation begins by reviewing the quiz to address the content of the reading assignment. This is followed by a discussion of current events concerning energy that students have been asked to search before class. A major part of the recitation is a discussion of a complex subject relating the energy topic of the week with how it is related to sustainable energy and sustainability generally. The last segment of the recitation is devoted to the homework assignment.

The homework each week consists of writing an essay, about two pages in length, on the assigned topic. Three of the essay assignments use the Calibrated Peer Review (CPR^4) process. Approximately 10 essays are written over the course of the semester.

Table 1: Course Lecture Topics in the first course section on Energy Basics

Week	Topic
1	Energy Overview
	Energy Overview
	Energy Conversions
2	MLK Day
	Energy for Heating
	Energy Storage
3	Steam Engine
	Internal Combustion Engine (Professor, Mech. Eng.)
	Turbines and Jet Engines
4	Electricity - A Historical Perspective
	Electric Power Generation and Transmission (Professor, Elec. Engr.)
	Austin Energy Initiatives (Fred Blood, Austin Energy)

Table 2: Course Lecture Topics in the second course section on Fossil Fuels

Week	Topic
5	Coal - the 19th Century Miracle Fuel Historical Environmental Issues Resource extraction and Power Generation
6	Oil - the 20th Century Miracle Fuel Oil Exploration and Production *Petroleum Geology (Professor, Petr. Eng.)*
7	Global Oil Production and Distribution Unconventional Oil Environmental Issues
8	Natural Gas - the 21st Century Miracle Fuel Global Natural Gas Supply and Distribution Unconventional Gas
9	*Petrochemical Products (Professor, Chem. Eng.)* *Energy Geopolitics (Professor, University of Houston)* Reading Day - No Classes
10	*Coal Liquifaction/Gasification (Professor, Chem. Eng.)* Global Warming

Table 3: Course Lecture Topics in the third course section on Alternative and Renewable Energy

Week	Topic
11	*Nuclear Energy Basics (Professor, Nuclear Eng.)* *Nuclear Energy Record (Professor, Nuclear Eng.)* *Nuclear Energy Future (Professor, Nuclear Eng.)*
12	Hydroelectric Geothermal *Water and Environment (Professor, Civil Eng.)*
13	*Energy from Biomass and Waste (Professor, Chem. Eng.)* *Energy Use in Agriculture (Professor, Agricultural Economics)* *Emissions Reductions in Texas (Professor, Architecture)*
14	Wind Solar *Hydrogen (Professor, Nuclear Eng.)*
15	Energy Sustainability Wrap Up

In the beginning, the recitation professor formulated the essay prompts based on the recitation discussion and emailed them to students a day or two later. Students were expected to turn in the essays by midnight Saturday, and they were returned to the students in the following recitation. In the third semester when an additional regular student recitation section was added, it was

found necessary to formalize the essay prompts to provide consistency among multiple recitation sections.

It has been a challenge from the beginning to engage students in stimulating discussions. Facilitating discussion is not necessarily a natural skill of professors who have for years been conditioned by lecturing themselves. Neither is it easy for GTAs or UPTs who have similarly had one-way lectures and have not experienced interactive engagement or cognitive apprenticeship environments. At the beginning when the professor, GTA, or UPT were not doing the talking, often one or two opinionated students tended to dominate discussions and perhaps be intimidating to the other students, a few of whom would almost never speak during the entire semester.

For a while PowerPoint slides were used as talking points for the recitations, but frequently these served more as a means for lecturing rather than as a mechanism to stimulate discussion. Gradually, fewer PowerPoint slides have been deployed. At the same time, beginning in spring 2007 recitation classrooms have been equipped with computers so that students can actively search for information while conducting discussions. The teaching team has now recognized the importance of streamlining the recitation process by aligning the recitation discussion with the essay assignment. This conforms more to the way the original recitations were conducted with the difference that the discussion subject comes from a pre-designed essay prompt instead of the other way around.

Until now the students have had 3 exams each semester that also served to partition the course into 3 segments. The first exam covered the energy basics as shown in Table 1. The second exam covered fossil fuels, and the last exam emphasized alternative and renewable energy and global warming considerations. The original exams each consisted of four essays, and honors students were given two hours to complete the exam during a recitation section. These exams were designed to exercise critical thinking skills while also demonstrating content knowledge. Once there was more than one section, the exams had to be administrated to all of the students during a 50-minute lecture period. The exams became a mixture of 15 multiple-choice or short-answer questions and 5 questions requiring a few sentences to answer.

Performance on exams has been disappointing for a majority of students, and the value of exams in this design of the learning process is not clear. This course requires a lot of reading and researching, and discussions vary from one recitation section to another. Also, the material in the lectures covers a broad range of topics, some given by guest lecturers. As a result, some students find it overwhelming to deal with the entire package of information and to synthesize it. Even though the short answer questions were designed to consider content information that students would be able to recall from its shear repetition, the students still found many of the questions difficult, and the teaching team has questioned the importance of some of the exam questions to the overall course outcomes.

In fall 2007 projects were introduced. To avoid overloading students, the projects were allowed to substitute for the last exam. After discussions among the teaching team, we plan to abandon all three exams beginning spring 08.

Reading, Writing – Energy

The overall vision for this project is to provide as many students as possible with education about energy resources, energy utilization, and implications for society that enables them to participate in long term energy innovations that will ultimately result in energy sustainability (ES) and an ever improving standard of living for the nation and for the world. The project objectives address two CCLI program components: creating new learning materials and teaching strategies, and assessing learning and evaluating innovations. The main enhancements for ENGR 101 planned under NSF funding were the addition of the honors project on ES, and allowing students to substitute the ENGR 101 for the freshman writing course on a pilot basis. The technique for expanding ENGR 101 from an honors course to a course for all students has employed ideas from Coppola's Cognitive Apprenticeship Model (CCAM)[2,3] to establish a horizontally and vertically integrated, diverse and well-trained instructional team including undergraduate peer teachers (UPTs), graduate teaching assistants (GTA's), and faculty members.

Before explaining the RW-E concept, it is important to explain the context for the ENGR 101 course. This course is a requirement for the Energy Engineering Certificate Program (EECP), which has been introduced as an option for engineering students and for suitably prepared non-engineers in fall 2006. The level of interest both from students to pursue the EECP and from employers to hire those who do will help to rationalize timing for eventual introduction of an Energy Engineering degree program.

The need to understand energy resources, their utilization, and their importance for society is profound, and energy research should seek not just incremental, but truly transformational changes. The psychological literature tells us that creativity is not something that just happens. It is the result of making unexpected connections between things we already know. Hence, creativity depends on our life experiences. Without diversity, the life experiences we bring to an engineering problem are limited. As a consequence, on their own engineers may not find the best solution or the elegant solution.[5,6]

The energy engineering certificate, a minor in Energy Engineering, and ultimately major degree programs will not be easily accessible to non-engineers on campus and will focus mainly on engineering. However, the overall vision for the ENGR 101 course would imply a need to reach out and attract the interest in energy of students from diverse majors like economics, sociology, education, architecture, business, and others.[7] The vision as stated would apply to a minor in Energy Studies, which would be, in turn, quite aligned with a goal to stimulate research and technology development toward transformational energy solutions. A long term goal to stimulate research and technology development toward transformational energy solutions will best be addressed not just by the College of Engineering, but by a campus wide effort.

The rationale for RW-E came from students in the trial course in spring 2006 who said that they were doing more writing in ENGR 101 than in a freshman writing course. When the coordinator for the standard freshman English course requirement was asked the question whether ENGR 101 could substitute the freshman composition course, ENGL 104, there was an enthusiastic response to definitely try the idea out as a pilot in fall 2006. The goal is to make the ENGR 101 course accessible to as many students as possible. As a natural science core curriculum elective, the ENGR 101 course must be an add-on over and above graduation requirements for most

engineering and science majors because their natural science courses are rigidly prescribed. This could discourage these students from taking the course, even though they would find the subject interesting and useful. Allowing substitution of ENGR 101 for the standard freshman writing course would enable engineering and science students to take the course as part of their required curriculum, thereby achieving a diverse mix of students from science, technology, engineering and mathematics (STEM) and non-STEM majors.

The College of Engineering relies on traditional writing courses from the English department in the freshman engineering curriculum, and professors and administrators are dismayed by the difficulties many students have with writing. Musgrove[8] notes that STEM students seem to lack writing skills, but observes that "We found that students are more motivated and conscientious about writing when they're writing about things they care most about". Further, consistent with our own observations with the trial first offering of ENGR 101, others also noted that students learn STEM subjects by writing about them.[9,10] Figure 2 offers a conceptual depiction of the rationale for the RW-E initiative.

Figure 2: Rationale for multidisciplinary energy courses and programs

The ENGR 101 course has attracted students with widely varying interests and skills, and lecturers in the course will draw from varied backgrounds. Like nutrients in the soil, as varied multidisciplinary skills feed the root competency of energy sustainability, the fruit will be energy innovation. Innovations are greatly needed to answer growing energy needs, and they will stimulate the level of interest in energy courses and programs.

RW-E Project Plan Execution

The RW-E logic diagram shown in Figure 3 provides an overview for this project. Following is a discussion of each of the key logic diagram elements.

Input

Inputs to the project include the Coppola Cognitive Apprenticeship Model (CCAM), the Reform Teaching Observation Protocol (RTOP[11]), the University Writing Center (UWC), Calibrated Peer Review (CPR), the Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP[12]), and the Institute of Applied Creativity (IAC). The RTOP and Visual Physics[13] applications were evoked originally in the project. The UWC has been highly supportive of this project, especially by participating in the first UPT and GTA training workshop during the summer of 2007, which also included brief training in CPR by the university CPR coordinator. Up to now the STEP and IAC programs have not provided significant input to this program other than sources for ideas and best-practices.

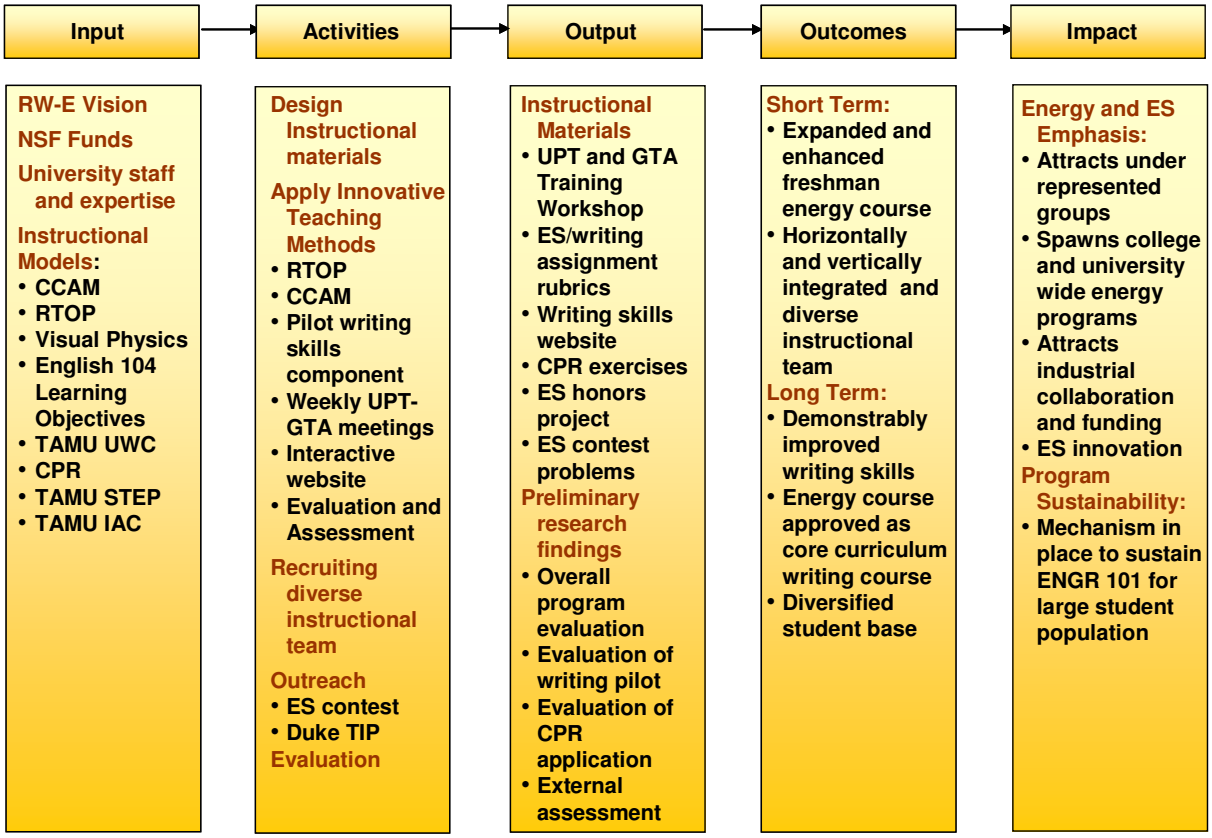

Figure 3: RW-E Project Logic Model [Abbreviations: Cappola Cognitive Apprenticeship Model (CCAM), Teaching Observation Protocol (RTOP), TAMU University Writing Center (UWC), Calibrated Peer Review (CPR), TAMU Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP), TAMU Institute of Applied Creativity (IAC), Undergraduate Peer Teacher (UPT), Graduate teaching Assistant (GTA), Energy Sustainability (ES)]

Activities and Output

Project activities have touched on all of the elements listed in the logic diagram. This section will consider teaching methods, weekly meetings, instructional materials, outreach, and some preliminary research findings.

Teaching Methods

ENGR 101 uses the following methods to help students learn: textbook reading, quizzes, lectures, discussions, student research, essay writing, and projects. The course has been planned from the beginning to eventually accommodate large numbers of students.

The decision to have UPTs conduct recitation sections was inspired by the example of Brian Coppola at the University of Michigan. In spring 2007 three GTAs were added to the teaching team: an MS level aerospace engineering student, Alex (pseudonym), to assist with the honors recitation section and two PhD level physics students, George (pseudonym) and Cato (pseudonym), to team teach the regular student section. Two UPTs, Bill (pseudonym) (psychology major) and Molly (pseudonym) (political science and economics major) were hired to teach a regular student section in fall 2007 so that the honors recitation section was taught by a full professor and Alex, one regular student section by the GTAs and one by the UPTs. Lectures were taught by two full professors with guest lecturers from a number of departments and from

off campus. This was the first semester that involved the entire vertical integration from undergraduate to graduate student to full professors. The team also included two new learning scientists: an assistant professor in Teaching, Learning, and Culture (TLAC), and a PhD candidate also from TLAC who replaced the previous learning scientists on the project.

Cognitive Apprenticeship approaches have been highly influential to the training of instructors for this initiative. Although the lectures are provided to all students as a group, the recitation sessions are meant to be taught as a student-centered interactive dialog. Textbook reading assignments, quizzes and lectures emphasize content knowledge. The purpose for the recitation is to teach the complex ideas of sustainability and sustainable development, particularly as they apply to energy through interactive discussion, writing, and team projects.

Weekly Planning Meetings

Weekly planning and debriefing meetings were conducted during spring and fall 2007 and were videoed in the fall. The weekly meetings have underscored the importance of planning the recitation activities. A trial practice of using a set of PowerPoint slides intended to reiterate the lecture material while serving as a mechanism to engage students in discussion was found not to succeed. Vernon (pseudonym), a graduate student in education, prepared materials for weekly meetings in spring 2007 to help the teaching team better understand various interactive engagement teaching techniques. Having observed some difficulties engaging students in discussion in the fall 2007 recitation sections, Vernon provided materials to the teaching team to improve their understanding of distinctions between mere content knowledge and expertise.

The current practice is scaffolding the recitation discussion on the subject of the essay assignment. This should motivate student participation in the discussion because it will help them formulate the points they wish to emphasize in their essays and find the references to support them.

Formative evaluation of teaching effectiveness and student learning takes place at each weekly meeting. Through this process the course has evolved continuously from a small strictly honors course to a much larger course dominated by regular students. Each semester offers summative evaluation from the students via the university Personalized Instructor/Course Appraisal (PICA) system. Student feedback has reinforced some approaches and provoked a need to reassess some others.

Instructional Materials

The design and preparation of instructional materials for the course has been an ongoing process. During the spring 2007 semester the project learning science professor developed a workbook for the summer UPT and GTA training workshops. Originally planned as a 3-day workshop at the end of the summer, the teaching team decided to have the workshops one day at a time to facilitate development and refinement of instructional materials for students.

The first workshop dealt with writing. A very real risk for a course basing much of the grade on written assignments is that students will be concerned that the grading is subjective. Indeed, students have remarked in student course evaluations that they felt instructors showed considerable bias in grading their essays. CPR was introduced to let students understand the peer review process and appreciate that writing skills can be objectively assessed. Having tried CPR two semesters, the recitation professor, and the GTAs were quite unsure whether they wanted to continue using the CPR assignments. Many, but not all, students dislike CPR. A major reason

they dislike CPR is that they don't trust the idea of students grading their work. A reason they like it is that CPR helps them appreciate how the essays are graded by their recitation instructors.

The purpose for the first workshop was to improve the alignment between essay prompts and the weekly lecture subjects, but an underlying concern was whether to discontinue using CPR. By this time the teaching team was appreciating the essential need for rubrics to guide essay grading, and they had developed rubrics for each of the essay assignments not using CPR. They did not feel essay grading was overly time consuming and certainly did not see value in using CPR just to reduce their grading load. Further, they felt that CPR was interrupting the weekly flow of the recitation activities. Once there were multiple but small sections, students from all sections were grouped together as peers, and it became necessary to take two weeks for each CPR assignment to allow students from sections taking place later in the week to have time to turn in their essays before the calibration and peer review steps could start.

The writing workshop began with an overview of the writing skills to be emphasized over the course of the essay assignments: Summary, analyzing visual rhetoric, analyzing arguments, taking a position, developing arguments, and synthesis. The project learning science professor presented instruction on how to prepare a rubric, and workshop participants worked on a rubric for one of the existing essay prompts. We were joined for this part of the workshop by the Director of the University Writing Center, who provided additional endorsement on the use of rubrics for grading essay assignments. She also offered tips on how to encourage students to use the UWC.

For the last part of the morning, the current TAMU CPR Coordinator presented how the CPR calibration and peer review work and how instructors can make the process more flexible or customized as needed. In the afternoon the teaching team reviewed the lecture schedule and assigned existing essay assignments to appropriate weeks. For a few of the essays this required a change of the writing skill to be emphasized and, therefore, a need to modify the essay prompt. Results of this exercise helped provide a basis for the recitation instructor and Alex to revise essay prompts and rubrics. At the end of the day, the decision was to continue using CPR for another semester, but the frustration level with this tool remained quite high.

The decision has been taken to abandon CPR for spring 2008 because much of the problem may be the quality of the CPR exercises. In the fall use of CPR may be resumed using new CPR exercises to be developed over the summer from existing essay prompts and rubrics.

The second training workshop dealt with employing interactive engagement strategies in recitation. While the honors recitation instructors had been fairly successful in engaging students in discussion, student course evaluations indicate students are not pleased with the discussions, and the first recitation section with regular students was quite disappointing to the GTAs. Clearly better methods were needed to facilitate discussion among the students. Further, the first UPTs were attending the workshops to learn how they would need to conduct themselves as recitation teachers. The workshop included practice on a number of interactive engagement strategies to acquaint the teaching team with various methods they could try.

The second workshop also included a section on the RTOP instrument. The intention was to use this instrument to assess the level of interactive engagement in some of the recitation discussions in the fall. The original project learning science professor was the main proponent of RTOP, and since her departure to the University of South Dakota, the RTOP has been replaced by a somewhat different approach because graduate level learning scientist felt that its emphasis on

problem solving rendered several of the measures unsuitable for the essay writing emphasis in ENGR 101. Instead, she has observed and recorded all the recitation sections three times during the course of the semester, each time followed by interviews with the GTAs and UPTs doing the teaching on their perceptions about teaching and learning. Qualitative analysis of these observations will be provided in another paper.

Gradually the new learning scientists are helping the teaching team appreciate how to apply Cognitive Apprenticeship to planning the recitation discussions. The two GTAs who taught the first regular student recitation section have been skeptical whether a discussion meant to be student driven can consistently and deliberately cover an intended subject. The team is learning how to develop scaffolding for the discussions that will enable development of stimulating, purposeful, and complex subjects. The decision to focus the discussion each week on the subject of the next essay assignment should motivate students to be more interested in the entire process. The scaffolding developed for the recitations should become a valuable part of the instructional materials developed for ENGR 101.

The third and final workshop was an orientation to prepare for the fall semester and took place right before the start of the semester. The teaching team agreed to have the students take an entry exam, not for credit, to evaluate what they knew, and the plan was to give them the same exam at the end of the semester to see what they answered differently by that time. We also agreed to use three short answer exams in place of the essay exams that were used previously. A major reason for changing the exam format was that multiple sections implied the need to use a 50-minute lecture period for each exam instead of the 2-hour recitation period that was available when there was only one recitation section. There was also an issue that UPTs would not be eligible to grade exams, leaving the task of grading increasingly large numbers of exams to a small group of professors and GTAs.

A key element that did not seem quite ready was the honors project. Interestingly, while the recitation professor and Alex were not sure how to proceed, George wanted his section to do projects related to plans for the University Olympiad. George had been working on ideas for University Olympiad since the previous spring. The University Olympiad program brings high school students to the campus to compete in exams and projects. The Olympiad is a way to acquaint good students with the university in hopes to interest them to apply to the university. The project idea we wanted to propose as a trial event was “Thinking Globally, Acting Locally: Sustainable Development in Your Community.” George’s idea was to have students propose projects under this theme, and he would use their project proposals to present to high school coaches in early November to see whether they would accept the trial event proposal. The UPTs also wanted to try this plan.

The recitation professor chose instead to cajole the honors section into doing a project instead of a third exam. He artfully prodded the students to consider the project as an opportunity to express themselves in their own way. Although this approach worked, now the team fully realizes the need for project guidelines, and the project has become endorsed by all as a meaningful and worthwhile effort for all students.

Other elements considered in the orientation workshop were the reading guidelines and weekly quizzes. Some of the original weekly quiz questions were regarded as difficult for a first reading of often more than 50 pages from the textbook. Cato had developed reading guides in the form of questions for students to emphasize in their reading, but some of the quiz questions came from

parts of the material that were not emphasized in the reading guides. Now good alignment between reading guides and quizzes has given students more confidence in their basic content knowledge.

At this point all course instructional materials have been drafted and some are still being refined. Blackboard provides an interactive website for the course, but work is in progress to develop an additional website with considerably more student input.

Outreach

The ENGR 101 course has been offered as a summer course in 2006 and 2007 in the Duke TIP program at the university. We look forward to continued involvement in this program.

As mentioned in the last section the outreach program we have selected is the University Olympiad. This program involves most Texas high schools. After the trial run this year, we will become eligible to promote a project competition endorsed by the University Olympiad.

Preliminary Research Findings

The intent of this paper is not to present research, but rather to describe the results of various activities conducted through NSF CCLI funding. Therefore, no formal evaluation of the program is offered at this time other than to acknowledge that all aspects in the project plan have been addressed as promised.

Regarding the writing pilot, in fall 2007 five students took ENGR 101 instead of ENGL 104. Although the English department offered to certify ENGR 101 as a substitute for ENGL 104, this concept has not yet been approved by the College of Engineering. The five students plan to take a CLEP exam to place out of ENGL 104. Their results were not available in time for this article. The expectation is that the College of Engineering will reconsider their opposition to this approach depending on the success of these students on the CLEP exam.

The jury is still out on CPR. Many students do not like it, and there may be problems with the exercises we have prepared. More work is planned on this before a decision is made to permanently abandon this approach because we do see value in it.

The external evaluation will begin in the next semester.

Outcomes and Impact

The short term outcomes of expanding and enhancing the energy course and establishing a horizontally and vertically integrated diverse instructional team have been achieved and are providing considerable value.

Progress is also being made on the long term outcomes. One way that may demonstrate whether students from ENGR 101 have improved writing skills will be to compare performance of petroleum engineering students who have or have not taken ENGR 101 in writing intensive courses they will encounter in the degree program. Approval of this course as a substitute for the composition course will take time.

Diversity of the student by one measure, that they come from a variety of majors, has been achieved from the beginning. The simple fact of the course availability has not attracted large numbers of students from underrepresented groups, and other mechanisms will probably be needed to achieve this outcome. We have had a small number of Hispanic students. To-date

women have been about 37% of the students in the course, but the last 2 semesters have been only 26% women.

Other impacts related to college and university wide programs and industrial collaboration and funding show promise but are preliminary to report at this time. As for innovation, students show many innovative ideas as a result of this course. Because they are not science students, their ideas may or may not have actual application. Nonetheless some students report in the course evaluation that this course has changed their interests and in some cases their major.

Conclusions

The RW-E project is accomplishing the objectives as planned, and various initiatives are proving enormously valuable to the ENGR 101 course evolution. Definitely, the NSF CCLI program has inspired this effort to aim very high in its ambitions. As the number of students seems to double each semester, it appears that after a slow start the course may indeed be reaching its intended audience. Continued growth is expected.

NSF CCLI funding has enabled the continued involvement of learning scientists in the course development. They have had a very positive influence on the course and on helping engineering professors develop a science course suitable for non-engineers, something most of them never do.

Bibliography

1. Donovan, M. Suzanne, Bransford, J. D., and Pelligrino, J. W. (Eds.). (2000). *How People Learn: Bridging Research and Practice.* National Academy Press, Washington, D.C.
2. Collins, A., Brown, J.S. & Newman, S.E. (1989). "Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics." In L.B. Resnick (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Erlbaum, Hillsdale, NJ.
3. Coppola, B.P. (2000). "Learning to Play a Rigged Game," The National Teaching and Learning Forum, Volume 9, Number 2, http://cstl.syr.edu/Cstl/NTLF/V9n2/carnegie.htm.
4. Simpson, Nancy (2005) Calibrated Peer Review, http://cpr.molsci.ucla.edu/
5. National Research Council. (2003). Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics. Committee on Recognizing, Evaluating, Rewarding, and Developing Excellence in Teaching of Undergraduate Science, Mathematics.
6. Lester, Richard K. and Michael J. Piore. (2005). *Innovation, the Missing Dimension*, Harvard University Press, Cambridge, MA.
7. Matyas, M. L. and Malcolm, S. M. (Eds.). (1991). *Investing in Human Potential: Science and Engineering at the Crossroads.* American Association for the Advancement of Science 91-39S, Washington, D.C.
8. Musgrove, L. (2006). "The Real Reasons Students Can't Write," *Inside Higher Ed*, http://www.insidehighered.com/views/2006/04/28/musgrove.
9. Moore, Randy. (1993). "Does Writing About Science Improve Learning About Science?" *Journal of College Science Teaching*, Volume 12 (pp. 212-217).
10. University of Pittsburgh. (2006) "Engineering and English collaboration serves as model for improving outcomes," *Teaching Times*, http://www.pitt.edu/~ciddeweb/FACULTY-DEVELOPMENT/TEACHING-TIMES/MAR2005/eng.htm.
11. MacIsaac, D. & Falconer, K. (2002). "Reforming Physics Instruction Via RTOP", The Physics Teacher, vol. 40, p. 479.
12. Jeffrey Froyd, Arun Srinivasa, Donald, A. Maxwell, Andrew Conkey and Kristi Shryock. "A Project-Based Approach to First-Year Engineering Curriculum Development Proceedings," Frontiers in Education Conference, 2005 http://fie.engrng.pitt.edu/fie2005/papers/1722.pdf.
13. Ezrailson, C. M. (2005). Visual Physics TA Training Program, http://www.coe.tamu.edu/~cezrailson/PhysicsTAWEB/TATrain.html