Sustainable Engineering for Urban Needs - Pre-Engineering Program Series

Instructor: Mr. Eugene Rutz, Academic Director, College of Engineering and Applied Science, University of Cincinnati

A pre-engineering program was taught by Mr. Eugene Rutz, Academic Director, College of Engineering, University of Cincinnati. Mr. Rutz manages the College's dual degree programs that provide both a B.S. and an M.S. or MBA. He also manages the collaborative effort with local high schools that provides pre-engineering course work and programs to various high schools[1]. Mr. Rutz also manages the colleges distance learning efforts and works with faculty to effectively use instructional technologies for teaching. He has been PI on state and federal grants related to technology and teaching and has contributed to other projects. He has presented numerous peer reviewed conference proceedings and published in the engineering education literature.

Goals and Objectives: This program describes the field of engineering and engineering technology allowing participants to explore technology systems and design processes. The overall goal of the program is to help teachers better understand engineering and engineering technology so that they can appropriately address engineering and technology related topics in their classrooms. A secondary goal is helping teachers understand the connections between science and math taught in schools and the use of these subjects to solve engineering problems. The content of the program includes topics that will enable participants to distinguish between engineering disciplines and to be knowledgeable about topics common to all disciplines. Learning objectives specific to each topic are listed in the Course Description.

Mr. Eugene Rutz Teaching During a Seminar

Format Used for Delivery: The program content was provided using a variety of means. Based on feedback from previous years, a project-based format was used extensively with some traditional instructor-led presentations used for a number of the topics. All presentation materials were available to participants before, during and after the sessions via the Blackboard web site.

As much as practical, interactive discussions between participants and the instructor were used to engage the participants. These were centered on the topic being presented while making use of an item

[1] Rutz, E., Lien, B., Shafer, M., and Brickner, S. (2008). Accessible STEM Education. Proceedings of the American Society for Engineering Education Conference. Pittsburgh, PA.

of current interest. For example, the impact of technology on society was framed around a discussion of the oil spill in the Gulf of Mexico.

Some topics were presented using web-based audio and video followed by discussions among the participants.

Project-based work was used extensively to develop the topics presented and provide opportunities for active learning for the participants. In most cases, participants worked in teams on projects to model the approach that would be used in the schools. The projects typically provided an open-ended problem centered around a topic (e.g., the engineering design process) and required participants to work together to solve the problem. Participant teams were then asked to provide an informal presentation of the results of their project work.

Course Description / Topics Covered: The RET program was modeled after the course developed for local high school students. The course uses the text *Engineering Your Future – A Project Based Introduction to Engineering*, by Gomez, Oakes, and Leone[2]. The text presents a broad and pragmatic approach to the practice of engineering and the study of engineering as a college major. The high school program is supplemented with instruction on the various engineering disciplines so that students better understand the similarities and differences between the disciplines.

The scheduling of the topics covered in the Pre-Engineering RET program is presented in the table below and described in greater detail following it. Also listed are the specific learning objectives for each topic.

Topic	**Date**	**Time**
Pre-engineering Introduction	June 24, 2010	11:00-12:00 PM
Working in Teams and Managing Time	June 25, 2010	11:00-12:00 PM
Engineering Design – The Design Process, Principles of Civil Engineering	June 29, 2010	9:00-11:00 AM
Energy Use and Selecting Among Alternatives, Technical Communication	July 7, 2010	9:0012:00 PM
Electrical Engineering / Computer Engineering / CS, Electrical Engineering Project	July 12, 2010	9:00-11:00 AM
Electrical Engineering Project	July 14, 2010	9:00-11:00 AM
Mechanical Engineering & Project, Materials Science & Engineering	July 21, 2010	9:00-12:00 PM
Engineering Tools, Technology, and Society	July 26, 2010	9:00-11:00 AM
TOTAL INSTRUCTION TIME	16 Hours	

Introduction to Engineering and Engineering Technology: In this session participants were introduced to the various disciplines within engineering and engineering technology. The disciplines

[2] Gomez, A.G., Oakes, W.C., and Leone, L.L. (2007). Engineering Your Future: A Project Based Introduction to Engineering, Second Edition. Missouri: Great Lakes Press.

were described so that participants are able to discern the attributes of the discipline and the application of the discipline. Equally as important, participants learned about the commonality in the disciplines and the interdisciplinary nature of engineering. The distinctions and similarities between engineering and engineering technology was also discussed. At the completion of the sessions, participants will:

- Describe the difference (and similarities) between engineering and engineering technology
- Associate an application of engineering and the discipline associated with that application
- Describe the fields of engineering associated with sustaining our urban needs

Working in Teams: In this session the concept of the multi-disciplinary team was discussed and the importance of this approach to solving complex problems. Issues of team development and time management were also presented. Participants participated in a team building exercise and developed a teamwork rubric that can be used in their home schools. At the completion of the session, participants will:

- Articulate a teamwork rubric appropriate for their use in the classroom
- Describe the characteristics of an effective team
- List the stages of team formation process

Engineering Design: In this session the participants were presented a model of the engineering design process and discussed its importance in developing appropriate solutions to complex engineering problems. A metric was presented for the evaluation of alternatives. Participants applied the design process using an activity that can be applied to their home schools. At the completion of this session, participants will:

- Describe a model of the engineering design process
- Formulate a set of evaluation criteria
- Apply the design process

Civil Engineering: In this session, participants were introduced to the study of civil engineering in the college setting and the practice of civil engineering. Emphasis was placed on the application of civil engineering to sustainable urban engineering issues. Important concepts were presented and discussed and the application of concepts was illustrated. Participants applied concepts in a project-based activity that analyzed energy use and how engineers affect energy use in buildings. At the completion of this session, participants will:

- Describe the practice of civil engineering
- List the various applications of civil engineering relevant to sustainable urban environments
- Apply engineering concepts to the analysis of energy use using a framework that is familiar to the participants

Technical Communication: In this session, the participants were introduced to a model of communication and discussed application of that model. Differences between technical writing and communication are compared with what students are usually taught in schools was described. Students used a spreadsheet to analyze data and then developed material to be communicated regarding this engineering analysis. At the completion of this session, participants will:

- Articulate a model of an effective communication process
- Enumerate the differences between needs of technical communication and a presentation made for a typical school class or project
- Develop technical presentation materials using Excel and PowerPoint

Reverse Engineering: In this session participants were introduced to systems engineering and how the idea of reverse engineering is used to determine characteristics of an item or system. Participants were given a reverse engineering project and asked to work in teams to complete the project. Resources and methods for presenting these topics were provided to participants. At the completion of this session, participants will:

- Articulate the process of reverse engineering
- Describe systems engineering and the value of this approach to solving complex problems
- Apply the reverse engineering process to a real situation

Mechanical Engineering: In this session, participants were introduced to the study of mechanical engineering in the college setting and the practice of mechanical engineering. The significance of mechanical engineering was discussed in terms of current topics, specifically the Tour de France bicycle race. Participants were asked to identify relevant solutions to bicycle gearing problems associated with speed and power. At the completion of this project, participants will:

- Describe the practice of mechanical engineering
- List the connections between mechanical engineering and other engineering disciplines
- Apply engineering concepts to the design of a bicycle

Electrical Engineering / Computer Engineering / Computer Science: In this session, participants were introduced to the study of electrical engineering, computer engineering and computer science in the college setting. The practice of electrical engineering was introduced using a web-based instructional module. Emphasis was placed on the application of electrical and computer engineering to consumer electronics. Participants were taught to solder and in groups of 2 constructed iPod speakers. At the completion of this project, participants will:

- Describe the practice of electrical engineering, computer engineering and computer science
- Describe the similarities and differences between electrical engineering and computer engineering
- Apply engineering concepts to the design and fabrication of speakers

Materials Science and Engineering: In this session, participants were introduced to the study of materials science and engineering in the college setting and the practice of materials science. Concepts were taught using both project work and instructional technology. Emphasis was placed on the application of materials science to sustainable urban engineering issues. Participants were introduced to material properties and required to use these concepts to in engineering calculations. Participants applied a number of the concepts through discussion of choosing among alternatives in an engineering design problem. At the completion of this session, participants will:

- Describe the practice of materials science and engineering
- List a number of concepts involved in deciding among engineering alternatives
- Apply engineering concepts to the analysis of structures

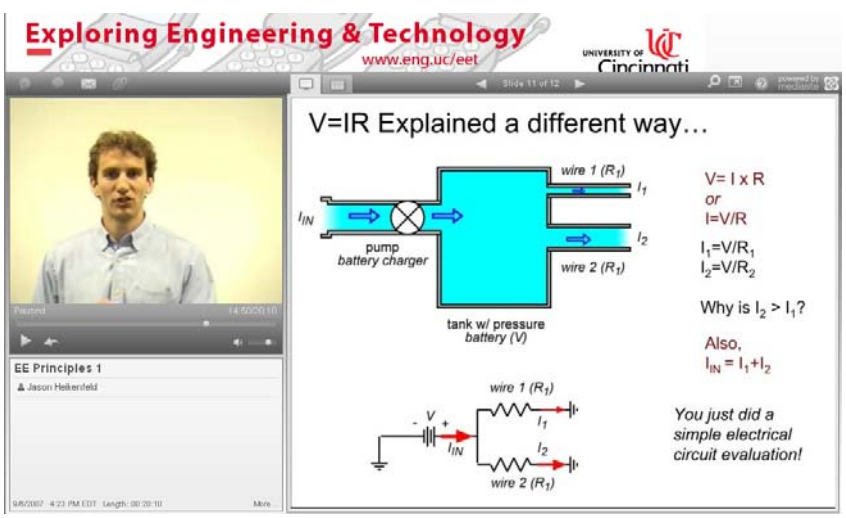
Engineering Tools: In this session, participants were introduced to a variety of design and analysis tools used by practicing engineers. Tools included those used for analysis (e.g., finite element, mathematical modeling), tools used for design such as CAD, and tools used for manufacturing. At the completion of this session, participants will:

- Describe the types of tools used in engineering practice
- Describe the math and science principles necessary for proper use of these tools

Technology and Society: In this session participants discussed the impact of technology on society and the engineer's role in appropriate use of technology. Web-based instructional modules were used to present material and facilitate discussion. Emphasis was placed on issues of sustainability and issues facing urban areas. At the completion of this session, participants will:

- Articulate technological challenges facing society
- Describe positive and negative impacts technological change can have on society
- List characteristics that need to be considered when implementing technological changes

The figure below illustrates a web-based instructional module used in the program:



Web-Based Instructional Module Used

Reflection on Program Content and Presentation: This program of teacher professional development complemented the research being performed and provided an added benefit to participants. The content of the Pre-Engineering program lends itself very well to the RET topics and helps participants make connections between projects and the practice of engineering. Within the pre-engineering program, an emphasis was placed on the use of math, science and technology by engineers to solve problems. Since the participants have a math and / or science background they are well prepared to participate in meaningful learning and meaningful discussions of the topics.

Project-based learning was appreciated by the participants and was used extensively. While it is important to include some traditional presentations, providing these in the context of a project is more engaging for the participants. The project-based activities worked quite well to teach the topics and illustrate the application of the topics. Spending time at the conclusion of the project reflecting on what was done and what was learned was also useful. It is also important for the instructor to clearly articulate the connections the projects have to the study and practice of engineering.

Lessons Learned: There were a number of lessons learned that will benefit the RET program going forward. These include the following:

- It is very useful to make explicit connections for participants on the relation between projects and particular engineering disciplines. They do not have enough background to make these connections for themselves.
- Participants were highly engaged when connections could be drawn between what was taught in their schools (math and science) and the principles and practices of engineering. These discussions led to greater exploration and sharing among participants on how best to help their students make these same connections. These discussions should be fostered and perhaps documented.
- For projects and engineering calculations, the participants worked in groups. This was helpful in that group members do help each other and contribute particular areas of strength. This practice though can contribute to a misunderstanding of the importance and function of teams as compared to groups. Engineering projects often require a team of interdependent individuals contributing while a group can rely on one “strong” contributor to accomplish the tasks. The teaching material on teams needs to be reinforced after group work so participants are clear that there is a distinction.
- The participants appreciated the project-based activities but also valued the traditional presentations especially when they were given in the context of a project. The participants are given so many topics and activities through the RET that care should be taken not to overwhelm them with either information or activities.
- Structuring discussions around current topics enables the participants to better appreciate the relevance of engineering professions to society. These discussions have to be managed well to keep the group on-topic but these explorations should be encouraged.