

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 schools¹. Mr. Rutz also manages the college's 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. 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.

Format Used for Delivery: The program content was provided using a variety of means. Based on feedback from the prior year experience, 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 of current interest. For example, mechanical engineering was introduced around the topic of gears, particularly gears on bicycles, with a discussion of gearing that would be appropriate for various stages of the Tour de France which was in progress.

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

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.

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 Leone². 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 **Table 1** below and described in greater detail following it. Also listed are the specific learning objectives for each topic.

Table 1. Pre-Engineering Program Schedule

Topic	Date	Time
Pre-engineering Introduction	June 25, 2009	1:00-2:00 PM
Working in Teams and Managing Time	June 25, 2009	2:00-5:00 PM
Engineering Design – The Design Process	June 30, 2009	2:00-5:00 PM
Principles of Civil Engineering	July 7, 2009	1:00-3:00 PM
Energy Use and Selecting Among Alternatives	July 7, 2009	3:00-5:00 PM
Technical Communication	July 9, 2009	3:30-5:00 PM
Electrical Engineering / Computer Engineering / CS	July 13, 2009	3:00-5:00 PM
Electrical Engineering Project	July 14, 2009	3:30-5:00 PM
Problem Solving Strategies	July 16, 2009	1:00-3:00 PM
Electrical Engineering Project	July 16, 2009	3:00-5:00 PM
Mechanical Engineering & Project	July 20, 2009	1:00-5:00 PM
Materials Science & Engineering	July 21, 2009	1:00-3:00 PM
Engineering Tools, Technology, and Society	July 27, 2009	1:00-3:00 PM
TOTAL INSTRUCTION TIME	28 Hours	

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.

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

Figure 1 below illustrates a web-based instructional module used in the program. **Figure 2** shows RET participants involved in an egg drop design competition.

Reflection on Program Content and Presentation: This program of teacher professional development worked well for the RET and complemented the research being performed. The content of the Pre-Engineering program lends itself very well to the RET topics at UC. 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.

College of Engineering - Distance Learning UNIVERSITY OF Cincinnati

Options Help

Polls Ask Slide Slide Show Slide List Max Slide

Paused 00:29/46:49

Engineering Communication Overview
Presenter(s): Eugene Rutz
Date: 9/1/2006
Time: 9:52 AM EST

Learning Objectives

At the completion of this module, you will:

- List core communication skills
- Construct a model of communication processes
- Describe the elements of that model
- Demonstrate ability to analyze problems in communication

For questions or technical support contact:
Eugene Rutz, Manager of ACCEND Programs
 513-556-1096 or Eugene.Rutz@uc.edu

Figure 1. Web-Based Instructional Module Used

The use of project-based learning was appreciated by the participants and could be used even more extensively. While it is important to include some traditional presentations, providing these in the context of a project would be more engaging for the participants. The project-based activities worked quite well to teach the topics and



2

Figure 32. Teachers Participating in an Electrical Engineering Design Project

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.

- The participants were most engaged with the project-based activities. While some traditional presentations were effective and well received it would be beneficial to incorporate the teaching, as much as possible, within the context of a project.
- It is necessary to make explicit connections for participants on how the projects relate to particular engineering disciplines. They do not have enough background to make these connections for themselves.
- The web-based instructional modules were also an effective means of presenting material and concepts. The use of this type format is a good supplement for in-person presentation but would not be an effective substitute for in-person presentations for this type of program. The modules used were relatively short – 10 to 15 minutes. This appears to be a good length to keep participants attention.
- Participants responded well and were highly engaged when connections could be drawn between what was taught in their schools and the principles and practices of engineering. It will be a benefit to include as many of these connections as possible.