

Pre-Engineering Program Series

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

A pre-engineering program was coordinated by Mr. Eugene Rutz, Academic Director, College of Engineering and Applied Science, 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. 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.

Format Used for Delivery: Based on feedback from previous years, a project-based format was used. The topics and concepts were introduced using the framework of a project that the participants would complete. The instructor presented new content using the context of an engineering problem or a problem to be addressed. All teaching materials used during the projects were available to participants during and after the sessions via the Blackboard web site.

Interactive discussions were also used to engage the participants. These were centered on the topic being presented while making use of an item of current interest. For example, the bridge across the Ohio River in Cincinnati has been the topic of local news due to its age and heavy use. This provided an item of relevance to discuss the features and constraints civil engineers deal with in bridge design.

During the 2011 RET Site several instructors were used in the pre-engineering program. In addition to Mr. Rutz, two master teachers from local high schools presented sessions. Both teachers have taught the project-based engineering course in their high schools and both have led teacher development workshops in the past.

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.

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 below and described in greater detail in following paragraphs. Also listed are the specific learning objectives for each topic.

Pre-Engineering Program Schedule

Topic	Date	Time
Engineering, Technology and the Design Process Eugene Rutz, University of Cincinnati	June 26, 2011	9:00 - 12:00 PM
Civil Engineering and Bridge Design Brian Lien, Princeton High School	July 3, 2011	9:00 - 12:00 PM
Aerospace Engineering and Airfoil Design Dan Boles, Oak Hills High School	July 12, 2011	9:00 - 12:00 AM
Materials Engineering and Stress & Strain Eugene Rutz, University of Cincinnati	July 19, 2011	9:00 - 12:00 PM
TOTAL INSTRUCTION TIME	12 Hours	

Engineering and Engineering Technology and the Engineering Design Process: 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. 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 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 a model of the engineering design process
- Formulate a set of evaluation criteria
- Use the engineering design process

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.

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 required participants to design and construct a truss. 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 that are practiced by civil engineers

Aerospace Engineering: In this session, participants were introduced to the study of aerospace engineering in the college setting and the practice of aerospace engineering. The students applied engineering concepts to the design and construction of an airfoil. At the completion of this project, participants will:

- Describe the practice of Aerospace engineering
- List the connections between aerospace engineering and other engineering disciplines
- Apply engineering concepts to the design of a common aerospace structure

Material 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. Participants were introduced to material properties and required to use these concepts 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

Reflection on Program Content and Presentation: 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. 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.

The project-based approach was valued by the participants. While it is important to include new content, providing this 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.

The participants responded very well to the mix of instructors. While there had never been complaints in earlier sessions about the instruction for these sessions, it was clear that having peer instructors (experienced high school teachers) in addition to university personnel was viewed as beneficial and enjoyable by the participants. The high school instructors were well suited to answer questions and concerns regarding implementation of these types of activities in the school setting.

Lessons Learned. The pre-engineering program illustrated the importance of the following:

- Participants are more engaged when explicit connections are made between the math and science taught in their schools and the principles and practices of engineering. The articulation of these connections creates significant dialogue and sharing among participants on how best to help their students make these same connections.
- Use of peer instructors provides legitimacy to the concerns of participants and they serve as role models for implementing project-based and engineering design –based instruction in K-12 settings.
- Providing fewer engineering topics but providing a greater depth of exploration was well received by participants.
- Introduce concepts using the framework of project-based activities to engage participants and engender greater interest in the topic.
- 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.
- 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.