

AC 2008-915: ACCESSIBLE STEM EDUCATION

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Accessible sTEem Education

Abstract

The University of Cincinnati collaborated with four Cincinnati-area high schools (Mt Notre Dame High School, Princeton High School, Mother of Mercy High School, and Harrison High School) to develop and offer a program that introduced students at those schools to the practice of Engineering and Engineering Technology. The College of Applied Science and the College of Engineering worked together to provide content that would provide high school students a balanced view of the careers and opportunities available in Engineering and Engineering Technology. The goal for the course was that greater numbers of students would understand the practice of engineering and engineering technology and would choose to pursue these in their college studies. This paper describes the collaborative process used to design and implement the course.

Course Design

In response to inquiries from two local schools, the University of Cincinnati developed a working group with the goal of providing high school students a meaningful introduction to the practice of engineering. This group consisted of instructors and administrators from three local high schools along with faculty and staff from UC's College of Engineering. Initial discussions of the working group identified these goals:

- Have a course available in the high schools beginning fall 2007
- Participation in the course should **not** be limited to “AP level” students
- Current instructors would teach the course
- Participation in the course should lead more students to pursue college programs in engineering

The working group also identified the need to encourage STEM disciplines to the greatest number of students possible. The importance of including both engineering and engineering technology in the course content was evident. The College of Applied Science was added to the collaboration in order to provide the engineering technology emphasis needed.

The working group evaluated existing curricula and materials to determine whether such materials could be used for the proposed course. In addition to discipline specific resources, the materials reviewed included: Project Lead the Way¹, The Infinity Project², Tools of Discovery³, and Engineering Your Future⁴.

While these and other programs provide significant resources and have a history of implementation in schools, careful consideration was given to identifying resources that allowed the collaboration to meet the goals established. In particular, Project Lead the Way provided a very robust approach and is the “preferred approach” according to the Ohio Department of Education. However, the commitment of resources needed (time and funds) to adopt that approach led the working group to choose the approach provided by the Engineering Your Future, A Project Based Introduction to Engineering text⁴.

The working group embraced the project-based approach to presenting engineering and engineering technology to high school students for many reasons:

- High school students will be more engaged in active learning than traditional classroom lecture
- The activities will create curiosity and interest in other students and will (hopefully) lead to greater participation in future years
- High school instructors are better prepared to lead activities than teach a range of engineering topics
- Activities can better illustrate the practice of engineering than lecture only
- Project work can facilitate better appreciation of teamwork and communication skills

To augment the project work, the Colleges of Applied Science and Engineering developed instructional modules on a variety of engineering disciplines as well as topics that span all disciplines. These were developed to provide the specific instruction on topics that the high school instructors could not provide. For example, modules describing the engineering and technology disciplines were developed as were modules on engineering design, problem, solving and technical communication. A summary of the modules developed for the program are listed in Table 1.

Table 1 Course Instructional Modules

Topic	Number of Modules
Communication	3
Teams	4
Engineering Design Process	3
Civil Engineering	5
Mechanical Engineering	2
Materials Engineering	3
Electrical Engineering	4
Computer Engineering	1
Biomedical Engineering	1
Aerospace Engineering	3
Chemical Engineering	6
Co-operative Education	1
Information Technology	2
Technology and Society	4
How to Succeed in Engineering	2

The working group, particularly the high school instructors and administrators, engaged parents and alumni with careers in engineering and technology, to help with aspects of the course. Arrangements were made for guest lectures, demonstrations, and visits to companies.

The working group met monthly during the program development phase. The pedagogical approach (project-based) was a result of a highly collaborative process. Likewise, the choice of materials to use was informed by the experiences of all participants in the working group. The

core group was composed of two high school science instructors (one with an engineering degree), a high school technology instructor, and a program administrator (a degreed engineer) from the College of Engineering. The defining characteristics of the course are summarized below:

- The course is primarily project-based with students learning about the practice of engineering technology through hands-on activities. Table 2 provides a list of a number of the resources that were significant to this effort.
- High school instructors lead the in-class project-based content and provide some instruction.
- Projects are derived from the text chosen and publicly available materials from a number of organizations
- University faculty developed instructional modules on various disciplines of engineering and on topics that span disciplines (e.g. design process). These modules are delivered via the web.
- Opportunities for students to interact with practicing engineers are provided at various points in the course.

Table 2 Project Resources

Title	Type of Resource
Teach Engineering ⁵	Math, science, and technology lessons and activities
Try Engineering ⁶	Lesson plans for science and technology
Teachers' Domain ⁷	Lesson plans, activities, videos etc on science and engineering
California Industrial & Technology Education Consortium ⁸	Projects related to construction, manufacturing, transportation, energy and engineering
Project STEP ⁹	Lessons and activities in science, engineering and mathematics

Course Delivery

The initial delivery of the course began in Fall 2007 at the schools. A fourth high school also asked to participate in the course. Each school had a number of distinct characteristics that led to differences in how the course was presented. Significant attributes included the experience of the teacher, the classroom setting, the student population, and access to technology and resources. To serve students well, it was necessary to accommodate these differences. This was accomplished as follows.

While a common syllabus was developed for the course, each school had significant flexibility in when topics were presented and the amount of time spent on each topic. For example, at Princeton High School the course was led by an instructor from the technology education department. This instructor also teaches CAD as a normal part of the school year and he spent

several weeks instructing those students on CAD and its applications. The other schools did not spend nearly as much time on that topic.

Flexibility was also provided on the projects used to introduce the engineering topics. The schools were provided a notebook of projects that included multiple projects on one topic (e.g. civil engineering). Schools choose particular projects based on the needs of the students, the experience of the instructor and the resources available at the school.

The instructional modules were developed by the university faculty as streaming media presentations. These were made available on a Blackboard web site maintained by the University. Students and instructors at all school were given access to these materials. Since they were web-based, they were accessible at the students' and schools' convenience. Some schools viewed the materials as part of the in-class work; other schools assigned viewing of the modules as home work. Figure 1 is an example of one of the instructional modules.

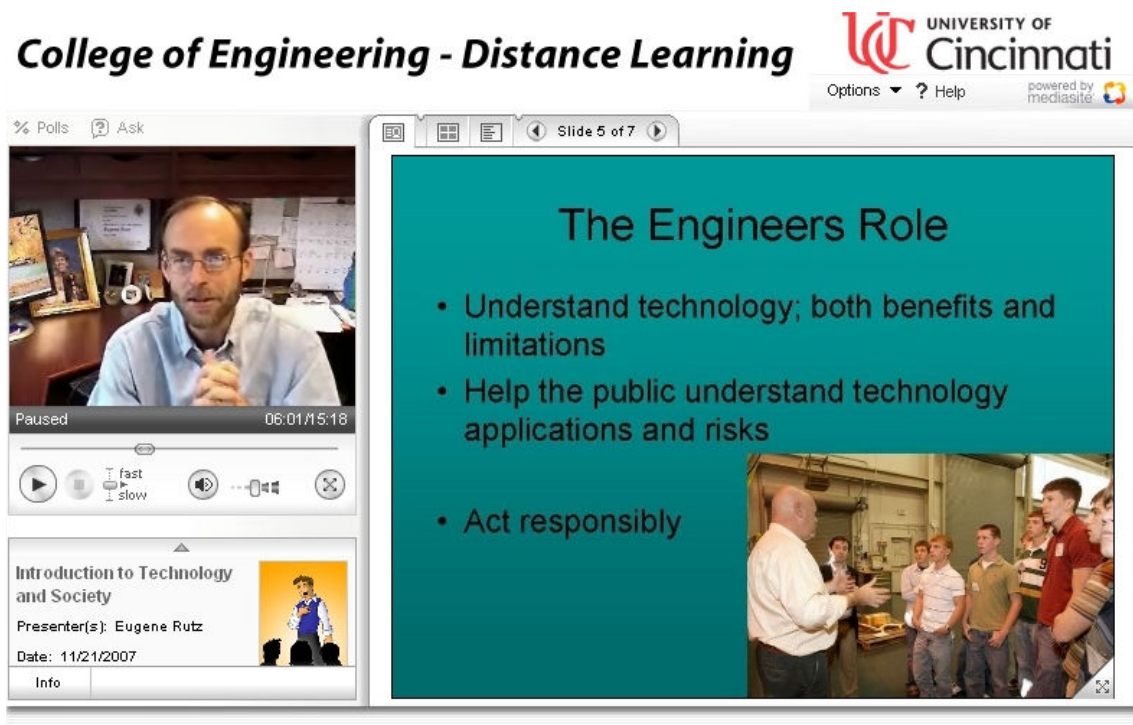


Figure 1 Instructional Module

As needs were identified, the schools contacted the university for help. For instance, one school opted to build a sterling engine as one of the projects. Instructional materials were needed that would help the students make the connection between the project and engineering technology concepts. New modules were developed on thermodynamics and heat engines and provided to the students.

Several common activities were included at which all students participated. Specifically, tours of facilities such as General Electric and Ethicon Endo Surgery. One visit was easier to

accommodate than multiple visits and this provided an opportunity for the students at the various schools to interact. Figure 2 was taken at the visit to GE where students learned about applications of aerospace engineering.

The collaborators continued to meet as the course was being presented. These meetings were valuable in identifying issues that needed to be addressed as well as providing formative assessment from the point of view of the instructors. The working group constructed a mechanism to capture lessons learned and best practices as the course was being offered.



Figure 2 Students Visit GE Aircraft Engines

Next Steps

The working group will evaluate the initial course offering to identify means to improve the educational offering. This assessment will include an analysis of pre- and post-course evaluations provided to students, a focus group discussion among the instructors, and comparisons between a control group of students and students participating in the course. Based on this evaluation, the course will be modified to improve the content and delivery.

The course is being made available to other schools for the 2008 school year. The collaborators will seek to include additional schools, particularly after the first develop – assess – modify cycle is complete.

Finally, the working group will seek to identify a venue to publicly host the instructional modules so that these are available to anyone interested in using them.

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