AC 2007-340: THE CINCINNATI STEM INITIATIVE

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The Cincinnati STEM Initiative

Abstract
The paper describes an innovative approach to providing high school students an introduction to engineering and technology. Educators from the University of Cincinnati and three area high schools have collaborated on the design of the course and the development of the curriculum. Characteristics of the course presented in the paper include providing the didactic materials through technology, using classroom time for hands-on activities, and using college students as mentors for the program. The course has been designed to be adaptable to the needs of the individual schools while being scalable so that additional schools can participate.

This is a new endeavor such that a rigorous presentation and evaluation of pedagogical effectiveness is not yet possible. Rather, the collaborative approach employed and the methods used to provide a course that is engaging to this student population are presented for discussion.

Background
The need to focus on effective Science, Technology, Engineering and Mathematics (STEM) education is increasingly recognized as an urgent national priority. While there is an urgent need to ensure the adequacy of the US science and engineering workforce, college enrollment in STEM disciplines is flat, particularly for women and minorities.

Many high school students choose not to pursue STEM disciplines due to a number of factors including:

- Lack of understanding of the nature of STEM opportunities
- STEM careers are seen as less relevant to society than medical or business careers
- Perceived difficulty of the programs of study

The University of Cincinnati is currently working with two all-girls' high schools and a large public high school with a diverse student body to develop and deliver curriculum that will engage high school students in STEM areas.

Mount Notre Dame High School [1]
Mount Notre Dame is a four-year comprehensive, college prep Catholic girls' high school located in Reading, Ohio, a suburb of Cincinnati. The student body is approximately 750 young women. Over 97% of recent graduates have gone on to two or four-year colleges.

Mother of Mercy High School [2]
Mother of Mercy High School is a four-year comprehensive, college-prep Catholic high school for young women located in a suburb of Cincinnati. The school has an enrollment of 611 students. The class of 2006 included 130 graduates, 97% of whom went on to post-secondary education. Mean ACT score was 23.2, while the mean SAT was 1051.

Princeton High School [3]
Princeton High School is a relatively large, four-year comprehensive high school that serves approximately 2,000 students. Academic program offerings span the International Baccalaureate program, through Technology, Business, and General Studies. Approximately 82% of the

graduates attend college with 60% going to four year schools and 22% enrolling in two year/technical schools. Princeton's average ACT composite for the past three years was 22.3. The average SAT composite in that same period was 1070.

For all three schools, the school year consists of two semesters with each semester divided into two quarters. Mount Notre Dame and Mother of Mercy use a block schedule with alternating days of four, 85 minute class periods. Princeton uses a traditional schedule with the school day divided into 7 academic periods.

Program Definition
The high schools indicated that their immediate need was to help students understand the engineering professions and to inform the students on how to prepare to be successful in college. After preliminary discussions, it was clear that this effort also needed to include engineering technology in the topics presented to the high school students. The collaborators concluded that the first step in this initiative would be to develop a course that would introduce engineering and technology to students.

The collaborators began an investigative phase of the project to identify and evaluate materials and curricula that were currently available and used by similar schools. In addition to discipline specific resources, the materials reviewed included:

Project Lead the Way [4]
Tools of Discovery [5]
Teach Engineering [6]
Engineering Your Future [7]
Imagine 101 [8]
Scientific and Technical Visualization [9]
The Infinity Project [10]

The review team was pleased to discover the significant diversity in resources to facilitate the new program. The collaborators refined their review to identify the most appropriate material given the following considerations:

1. Could be taught without significant, additional classroom materials
2. Would not require hiring additional staff
3. Would not require large expenditures to train instructors
4. Could be tailored to each school as needed

The University of Cincinnati contributors also sought a program that was scalable so that additional high school partners could be added as experience was gained with the program.

Given the considerations listed above and the primary objectives of offering an initial course that informed students regarding the nature of engineering and technology and engaged them in activities that would engender interest in the topics, the collaborators choose to use the approach provided by the <u>Engineering Your Future, A Project Based Introduction to Engineering</u> text[11].

Course Description
Once the approach and text were defined, the collaborators worked to define a syllabus that would meet the needs of the high schools. To meet the course objectives, students need to learn about the various engineering and technology disciplines and participate in activities that excite their interest in these disciplines. To utilize time and faculty experiences well, the collaborators decided: 1) in-class activities will primarily be project based and high school faculty will lead these projects; 2) the didactic materials regarding engineering and technology will be developed and presented by university faculty.

The following was developed as the course description for the syllabus.

This course describes the field of engineering and engineering technology allowing students to explore technology systems and design processes. Through the course students will use math, science, technology, and writing to solve engineering problems. The course is primarily project-based and requires substantial participation by all students. The course also emphasizes team work, oral and written communication, and the impact technology has on society.
The course is a two-semester sequence. The first semester can be taken without taking the second semester. Except in rare cases, the second semester can not be taken without completing the first semester.

Table 1 lists the topics to be covered in the course.

Table 1 Course Topics

Topics
First Semester
Introduction to Engineering and Engineering Technology
Working in teams / managing time
Communication: written, oral, presentations; Intro to Technical Writing
Communicating Ideas
Engineering in Context: Civil Engineering / Architectural Technology
Engineering in Context: Civil Engineering / Construction Management
2-D CAD
Engineering Design
Engineering in Context: Mechanical Engineering / Technology
Engineering in Context: Manufacturing
Problem Solving; Creativity
Engineering in Context: Materials Engineering / Technology
Information Technology
Succeeding in Engineering
Second Semester
Technology and Society
Problem Solving / Strategies
Engineering in Context: Electrical Engineering / Technology
Engineering in Context: Computer Engineering / Technology

Solid Modeling & Analysis
Engineering in Context: Biomedical Engineering / Life Science Technology
Co-operative Education
Engineering in Context: Aerospace Engineering / Technology
Engineering tools
Engineering in Context: Chemical Engineering / Chemical Technology
Engineering in Context: Software Engineering

The collaborators recognized that a survey style course can lack coherence and excitement. In order to avoid this lack of coherence and provide students a familiar framework for understanding the applications of engineering and technology, the design and operation of cell phones is being incorporated as a unifying theme. Contributions to cell phone design and use from various disciplines will be described. The broader context of each discipline will also be provided so that students understand the range of applications and occupations associated with various disciplines.

Given the project-based nature of the in-class experiences, the collaborators recognized the need to modify the traditional lecture / homework approach. In this course, students will receive content through instructional modules as "homework" (described further in the next section). Classroom time will be used for discussions, hands-on activities, and team-based activities – activities that might normally be carried out as homework.

The instructor's manual for Engineering Your Future has a wide range of well-defined projects (see www.glpbooks.com/download_files/fling_sample.pdf for an example activity). The high school collaborators will be able to complete many of the activities without supplemental instruction based solely on the instructor's manual. Other projects are available from professional organizations such as ASME[5] and SAE[12]. These will be incorporated as deemed appropriate by each individual high school.

To facilitate student engagement and interest, a number of relationships are being established with student and professional groups. For example, the UC chapter of the Society of Women Engineers has asked to serve as mentors for the high school students. Similarly, engineering honors students have community service requirements to maintain scholarships. A number of these students will work with the high school instructors on classroom projects. A network of practicing engineers in the region who are eager to share the excitement they hold for the profession is being developed. These individuals will make classroom presentations and facilitate visits to regional businesses.

Instructional Technologies

To facilitate the presentation of the teaching materials, instructional technologies are being used to develop much of the didactic materials for the course. The modules will be web-based so that they can be used by any school in the collaboration and can be accessed at the schools' (and students') convenience. Thus the material that is traditionally presented as lecture will be given as a homework assignment that a student must view prior to coming to the class. The University of Cincinnati is developing this material so that it is available for use beginning the fall semester of 2007.

The primary mechanism for content delivery will be streaming media lectures. These will be developed by the staff in the College of Engineering and hosted on a central server so that they are available to all students. Faculty have been instructed on this technology and every attempt is being made to develop modules appropriate for this student group. For example, lectures should not be longer than 15 minutes in duration. Figure 1 is a screen shot of one of the modules on communication that was developed using Sonic Foundry's MediaSite System[13].

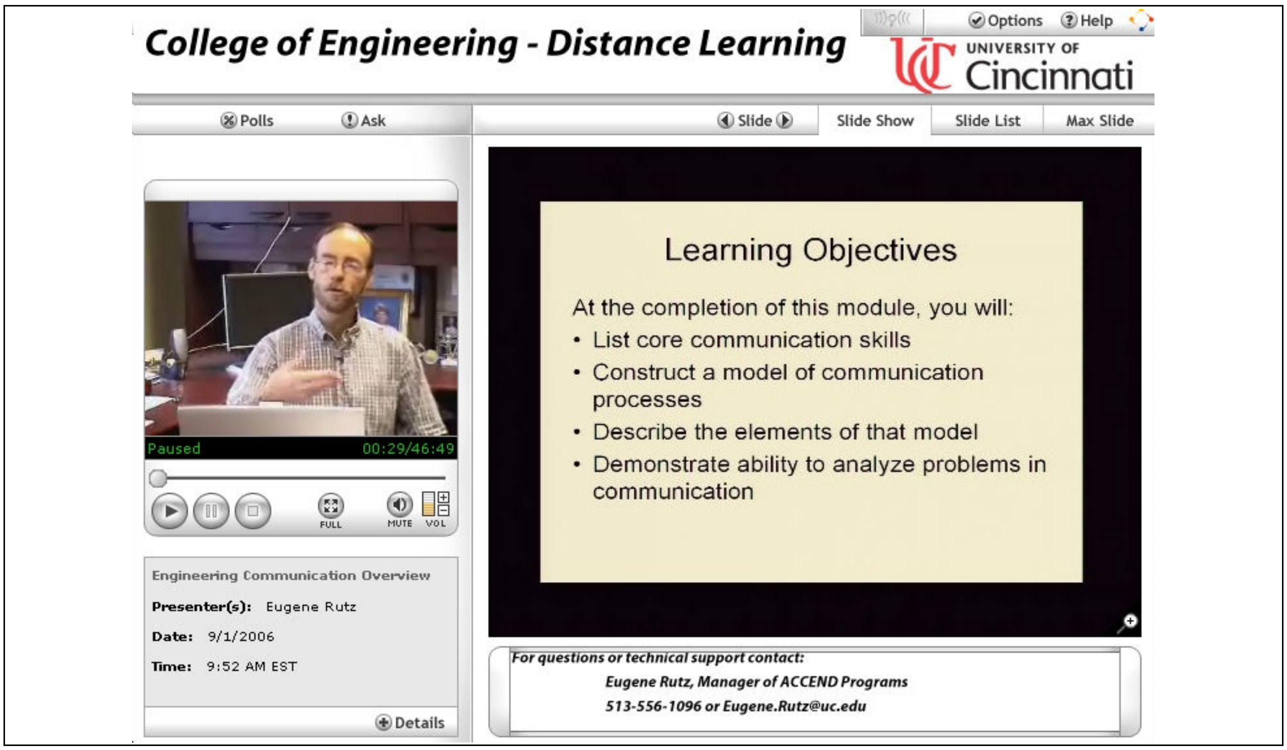

Figure 1 Technology-Based Instructional Module

In addition to the streaming media instructional modules, other technologies that appeal to this population are being used. Many of the lectures will also be available through pod casting. VOD casting (video on demand) is another option for students to receive select materials. The instructors can also use mobile messaging (sending a "blast" text messages to course participants) for announcements and instructions; and video broadcast to cell phones for special (limited number) presentations will be done to demonstrate this technology. The intent is not to "dazzle" the students or overwhelm them with options but rather to provide content in ways they will find interesting and engaging (and which they will share with their peers).

Students from all of the participating high schools will receive the content via a common Blackboard web site hosted by the University of Cincinnati. The site contains the streaming media lectures, presentation materials to accompany these lectures, as well as additional resources and web sites for further exploration. The Blackboard site will also be used to mediate threaded discussions and to facilitate group work.

A typical "homework" assignment will be for a student to view the lectures (2 or 3) associated with a particular topic. Typically each instructional module will be developed by a different individual at the university. Using chemical engineering as an example, the instructional modules include:

- Chemical engineering contribution to cell phone design and use
- The "world of chemical engineering and technology" (variety of careers and activities relevant to this field)
- Examples of current research in chemical engineering

Most of the instructional modules will also be available via pod casting. While the collaborators are not using (or encouraging) this as the primary means of content delivery, using this format provides students additional opportunities to interact with the content. Using technology to deliver content also enables the project to be scaled up to include other schools.

A number of the university instructors will visit the high schools to provide an opportunity for interaction and to share their enthusiasm for engineering and technology.

A Work In Progress

The collaborators are currently developing the course for presentation beginning fall of 2007. University faculty are scripting and producing the instructional modules. The project leaders are working with university instructional technologists to develop the variety of delivery mechanisms described earlier. High school faculty are selecting projects that fit their particular student population, budget constraints and resource limitations.

All collaborators are working to develop meaningful experiences for the students beyond the instruction and projects. Additional activities will include guest presentations by working professionals, visits to industry in the region, opportunities to use laboratory facilities at the university and participation in various outreach activities, such as JETS teams[14].

The collaborators will offer the course at the three schools beginning fall of 2007. Rigorous evaluation of both the students' experiences and the high school instructors' experiences are being conducted by an outside organization to help quantify gains made through the project. Based on lessons learned during this first offering, the course will be modified as needed. The next step will be to offer the course at additional high schools across the region and state. If this proves successful, the collaborators will seek to extend the course concept to other disciplines (e.g., mathematics) and to other grade levels.

The collaborators recognize that there is much to learn regarding how to effectively design and deliver this content to an audience of high school students. The project has been informed by similar efforts and by previous experience using educational technologies. Likewise there is much to learn regarding effective, sustainable collaborations between high schools and universities. The collaborators agree that this is a journey worth taking.

References

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