Bringing Engineering to High School Honor Students (College Institute)

Muhammad H. Kehnemouyi, Jane S. Storck, Gilad Sharon,
Montgomery College/ College Institute at Thomas Wootton High School/ University of Maryland at College Park

ABSTRACT*- Through the creation of a unique partnership between Montgomery County Community College and Montgomery County Public High Schools, the field of engineering has begun a year earlier for some college-bound students.*
In two area high schools college classes are offered to identified high-achieving seniors who desire to prepare for college by earning college credits in the environment of their own school buildings.
Competition for acceptance at colleges and universities is now more intense than ever. As AP classes continue for many, but are often limited in subject areas, these two high schools have discovered a new edge by offering college classes, such as engineering.
For the past three years the College Institute has had much success and the competition to enroll in one of the engineering classes is intense, since only twenty students are allowed to enroll every semester. With the interest that is generated, it has ensured one class each semester as well as a wait list. Benefits from this early exposure provide students with an excellent frame of reference for beginning a major in the field or determining that their efforts should be placed elsewhere. College faculties teach these credit classes with the same rigor as the campus-based course. Since many engineering programs have moved to five year plans, this allows eager students to get a head start at the reasonable tuition rates of the community college. Exposing each educational institution to the standards and practices of the other has also been a benefit which has produced better understanding and positive relations.
Success is not earned without challenges that must be overcome. Creating workable schedules is but one of those challenges. High schools have different class period allocations than colleges. A workable arrangement was achieved as the high school worked to provide the necessary time and space for a college engineering class.
Proper computer lab and lab space was also an obstacle, since high schools only maintain high school levels of such labs. The college provided wireless classroom. Safe storage was provided by a mobile, electrified cart that was stored in an adjacent room. The students not only received staff instruction and computer space, but also found sufficient room for design project construction in the high school

For the past three years Montgomery Community College, Gaithersburg and Wootton High Schools in Montgomery County, Maryland have jointly operated a special program entitled "The College Institute". Identified high achieving seniors from each high school are encouraged to participate in the College Institute Program. This program allows exceptional seniors to fulfill all of the requirements of college classes and earn college credits, while still attending their regular high school. Even though AP classes and their corresponding exams are more and more available to high school students, they are often limited by subject areas. These two high schools have discovered a new way to enhance the senior year and enrich a student's individual college profile, by offering the opportunity to take credit college courses such as engineering during their

senior year. This paper addresses this special engineering program from its inception into the future.

The students who are eligible to participate in the College Institute are selected according to the following criteria.
Any student who by the end of their junior year has:

- Completed primarily all high school graduation requirements,
- Achieved a minimum verbal score of 550 and minimum math score of 550 on the SAT,
- Earned a minimum weighted grade point average of 3.5, and
- Received the recommendation of the high school guidance counselor.

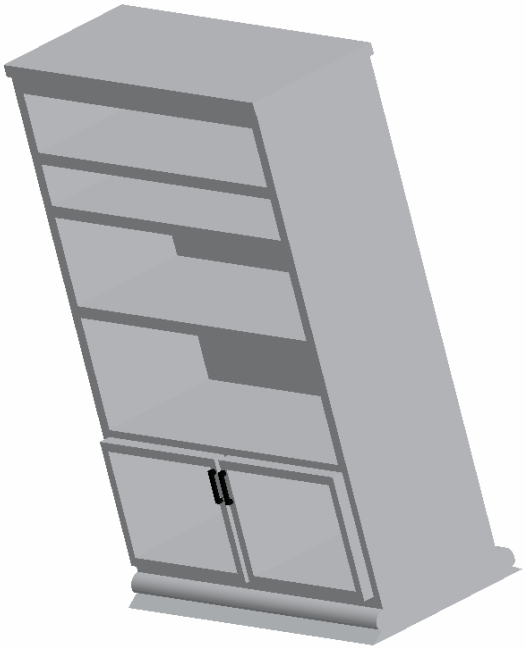

Figure 1

The Engineering Program at the College Institute consists of several courses. The first of these courses is "Introduction to Engineering Design". The Engineering Design course consists of four related modules**.** The first module deals with three-dimensional graphics. Some of the topics that are covered in this part are: Isometric and Oblique Systems, Auxiliary Views, Dimensioning, Tolerancing, and Threaded Fasteners[1].The second module concentrates on the operating principles of three dimensional, solid-modeling techniques, employing a sophisticated computer software program, ProEngineer. Basic part and assembly creation concepts are taught in a "click-by-click" approach on laptop computers provided by the college for use in the computer lab[2,3].

Figure 2

Figures 1 & 2 show sample parts created by the students using the ProEngineer program.

The third module emphasizes the importance of electronic spreadsheets in engineering[4]. This module also allows the students to practice their presentation skills that will be essential during their group project presentations. To integrate all the separate modules of the course, the students are required to design and build a team project that is assigned to the entire class[5]. This final project consists of a written report, a group presentation and a demonstration of a working prototype.

Figure 3 shows a sample of a prototype created by a design team. The goal was to design a machine that can propel a one-inch diameter wood sphere from a launching area over a barrier and into a container located on the other side of the barrier.

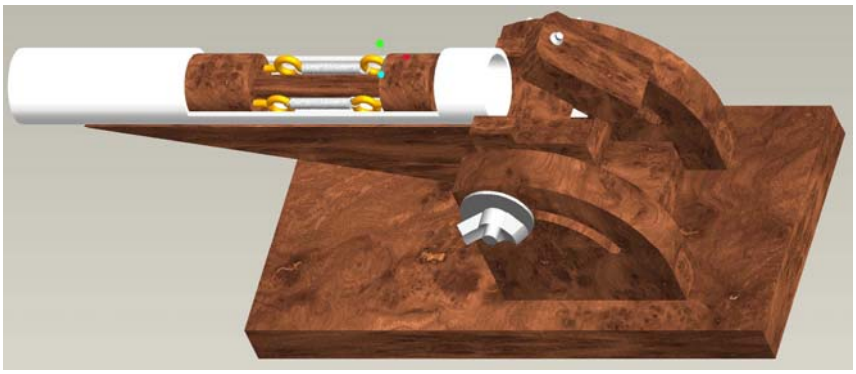

Figure 3

Acceptance into a top engineering school is extremely challenging. Families understand that the competition for the top schools is intensifying every year. High School graduates need to have an edge to get accepted into the school of their choice. The College Institute provides this advantage by offering academic challenges in addition to the traditional AP courses. The College Institute allows students to start their college engineering education one year earlier than usual. Since engineering is rapidly becoming a five year program, a student who starts early could still finish in four years. At the end of the program, the students receive college credits that are transferable to any institution. All courses are taught by experienced college professors. Even though they are a year younger than most college freshmen, most students are successful in the class, because they are exposed to a college experience in a high school environment.

The College Institute experience has not only introduced these high school students to the field of engineering, but it has generated a greater amount of interest in the whole topic of engineering at the high school level. To date, nearly one hundred high school students have successfully completed the Introduction to Engineering Design course by earning a grade of B or better. These students did not just earn good grades but also acquired a host of valuable skills in a short period of time. Some of the students created group projects that were clearly well beyond the scope of what was expected in this class. These students were encouraged to use their creativity to the fullest extent and were offered "open lab time with the instructor" so they would have the additional time that would be necessary. Some of the prototypes created in the design studio far exceeded our expectations and requirements, especially in the amount of time and energy the students devoted to their project.
Figure 4 shows one of these works.

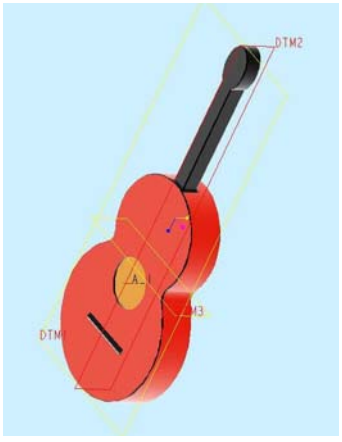

Figure 4

Additionally, this early exposure to college courses has revealed that these young students have developed a longer term interest in the field, as evidenced by their designation of desired major on a College Institute career survey. From the "Montgomery County Public Schools High School Senior Exit Survey of the Class of 2005", published by the Office of Strategic Technologies and Accountability, it appears that Engineering was one of the top three areas that College Institute

students chose as "their expected field of study or career choice. Engineering was second only to the field of Law & Government by 26% .vs. 21%. This strong interest can partly be attributed to the early exposure to the field of engineering during high school. The students not only receive an early opportunity to take pre-engineering courses at the high school level with a high school teacher who coordinates his class with the college's curriculum to better prepare students, but they have the unique opportunity to take college engineering courses in their senior year under the guidance and direction of college professors.

Even though it is early to judge whether these students really know what the future holds, they seem quite confident that they must excel in order to be successful in this competitive field. When questioned "What is the highest degree you expect to receive?", 49% expected to receive a doctorate degree, 38% expected to receive a Masters degree and only 13% a Bachelors.
It also seems evident that parents, along with teachers, school counselors, and admired persons in the field were most influential in helping these students choose their career direction.
When questioned "In planning your future, how helpful were each of the following people: Parents, Other Family Members, Teachers, School Counselors, Friends, Work or Internship Supervisor and Admired Person in Field, students chose "very" or "somewhat" 74% of the time. These parents and other influential people were recognized by the students as playing an extremely important role in deciding to take a college class during high school.
Many engineering students seem to be driven by prior interest or aptitude in this technical field, along with such influences as an outside job, a guest speaker, and courses taken, as evidenced by 78% of the respondents who thought that they were either "very" or "somewhat" helped by these categories. Students seemed aware of the realities of the working world today and the need for information about job availability and financial aid, as 52% indicated that these two factors were significant in planning their future.

Many of the students enrolled in the engineering program at the College Institute continued to pursue engineering as their undergraduate major when they entered colleges and universities following their high school graduation. Although there is currently no formal data available on where each of our former students decided to matriculate after their graduation from high school and which major they decided to elect, from personal contacts, we have determined that some of them stayed in the Maryland area and some went on to attend the nation's top engineering programs such as MIT and Georgia Institute of Technology.

The birth of this engineering program at the College Institute was not without its problems. There were many logistical efforts that had to be coordinated between the high school and the college. One such problem was solving scheduling conflicts. The college schedule is set up so that classes run at certain times of the day and only on designated days of each week. In contrast, the high school system has 45 minute periods, followed by 5 minutes between classes. It took much planning to align the student's regular high school classes with the college class meeting requirements.

To facilitate teaching the first engineering course in the high school environment, it was also necessary to address the essential issues of equipment and space. It was necessary for the college to provide some specialized equipment to the high school facility because their school computer system was not able to support the three dimensional design and solid modeling packages. It was

decided that the course could be taught in a portable and wireless lab setting. Twenty five DELL M60 notebook computers were purchased, along with a projector and some other accessories. The shared responsibility for the lab equipment forced the staff from both the college and the high school to follow special procedures. The computers could only be used under the supervision of a College Institute staff member. For obvious security reasons, the laptops needed special theft and handling procedures. For that reason a specialized electrical storage cart was purchased that could be locked while the computers were being recharged after every class and was also easily accessible when they were needed for use during the class.

Figure 5 shows the portable lab setting that is used.

Figure 5

The second issue that these two institutions needed to address was space. In order to meet the needs of this college course with the realities of the high school facility, the team had to be creative. The necessary shop space was located in a high school room (previously a woodworking shop). This space was allocated to establish an engineering design studio at the high school. Raw materials and many power tools were purchased for the facility. Items such as band saw, drill press and several power tools were already present at the high school. Figure 6 shows part of the design studio.

Another unique feature of this program centers around the support offered to each student. The students are required to enroll in a one semester "Transition to College" course, administered by the college. They pay a one credit hour fee and all materials are provided for them. This class meets once per week and is scheduled for a day and time that does not conflict with the student's college course. The topics covered during this class include: Time Management, Money Management, Career Choices, Campus Facilities, College Resources, Faculty/Student Relationships, Transferring Credits, and others. Making the transition from high school to college is certainly enhanced by this one credit seminar course.

Figure 6

After successful completion of the introductory engineering design course, the students may take the next course in the engineering sequence, Engineering Statics. The early completion of this

course increases the probability of that a student can finish an engineering program in 4 years and allows the students more course flexibility at their university.

Looking ahead to the future, our plan is threefold: to offer engineering courses beyond Engineering Statics, to expand the program to the junior year in high school, and the recruitment of more females into the program.

Bibliography

1. "Introduction to Engineering Design, Lecture notes", M. Kehnemouyi, J. Swearman, Montgomery College Rockville, Maryland, 1995
2. "Parametric Modeling with Pro/ENGINEER (Release Wildfire 2.0), Randy H Shih, Schroff Development Corp. (SDC) Publications, Mission, Kansas May, 2003,
3. "Pro/Engineer Wildfire Update Training Instructor Guide, release 2002", PTC Global Services Education, Needham Mass. 2002
4. "Excel for Scientists and Engineers", William J. Orvis; SYBEX, Alameda, CA,1996
5. "Engineering Design, A project Based Introduction, Second ed.", Clive L. Dym, Patric Little; Jhon Wiley&Sons, Inc. New York, NY, 2000

Biographical Information:

Author

MUHAMMAD KEHNEMOUYI is a professor and chairman of the engineering department at Montgomery College. He has a M.S. and PhD. in Mechanical Engineering from the George Washington University in Washington D.C.

Co Author

JANE S. STORCK is a Social Studies teacher in the Montgomery County public school system. She is currently the program coordinator of the College Institute, Coordinating the high school operations with the college.

Co Author

GILAD SHARON is a senior Mechanical Engineering student at the University of Maryland, College Park. He has an A.S. degree from Montgomery College, Rockville. For the past three years he has been working in the Engineering Department of Montgomery College as a teaching assistant.