# Linking College Engineering Courses With High School Preparation

**Donald L. Goddard PhD PE**

**The University of Texas at Tyler**

## Abstract

A Report titled "Expanding the Technology Workforce"[1] prepared by the Texas Higher Education Coordinating Board found that :

> "…Texas Students are not being sufficiently informed nor prepared for some of the most interesting, challenging, and lucrative careers in the new economy"[1]
> "The recruitment of top quality high school students to the engineering profession is an area which needs to be pursued…"[1].

The insufficiency noted in the above referenced report, which can be best directly addressed by colleges of engineering, is the matter of informing the students at the high school and junior high school. Many of these students have a bright interest in science but no goal or realistic grasp of what they would do with what they learn in high school science courses, even though the courses are available to them. Since those courses are often the more demanding, motivation is highly important. This paper presents the methods used at UT Tyler to address this problem. These methods integrate a component into junior and senior level design courses that places the college engineering students in high school classrooms. There, these students then explain actual engineering design projects and the field of engineering to students who can be motivated and recruited to the engineering profession.

## I. Background

An electronic search was performed at the web page "Search the Journal Engineering Education Database" which allows searching for articles in the ASEE Journal of Engineering Education. The search was executed using the search words "high school" and yielded 128 "hits". Amazingly, in the entire 128 hits not a single paper had the term "high school" in the title. I assert that this is amazing because of the number of my colleagues who complain about the quality and quantity of students coming into our programs, how ill prepared these students are, and how uninformed they are about engineering. These concerns barely address the matter of the students who might have come into engineering and did not because they had no idea what it really was. This experience in searching the database only adds to my conviction that there is a neglected area in which engineering educators can be acting, where they are received warmly, and where they are able to enhance the lives and learning of both their current and future

students. I will attempt to show one way in which this avenue has been and can be successfully exploited to the benefit of all.

It is doubtful that anyone would seriously argue that the average student who wishes to pursue an engineering curriculum, and who sets foot on campus without being fully "calculus ready", is behind in his preparation for college. Indeed one can make a credible argument that being advanced in calculus before starting the freshman year is highly desirable and would be a preferred standard. Because of its key position in the "chain of prerequisites", calculus is highly visible; but there should be little doubt that having high school introductory courses in areas such as physics and chemistry are equally important, not to mention the value of other areas such as technical drawing etc. An appalling number of students visit our campus and my office who have finished high school and are unprepared for the engineering program they now want to pursue. They have finally realized that their orientation for a career is towards engineering, but they are woefully unprepared because they did not take the right courses in high school or even junior high school.

If we as engineering educators are to reap our share of the best students coming out of high schools, then we must go to that body of students and help them prepare. Since this requires time and effort, where in our busy schedules can we find it. What I propose here is a program that is working and is not consuming a gross amount of effort needed elsewhere.

The core idea of this program is simple: take the college students to the high school. In various engineering classes, it is common to require the students to make a presentation of their work. Why can't some of those presentations be in the high schools? Just because the high school students are not potential employers or practicing engineers does not mean that such a presentation lacks educational value to the engineering students. The engineering student must learn to assess his or her audience's needs, interests and capacities. Just because the high school students have not had technical education and work experience does not mean that they are incapable of asking challenging technical questions. The opportunity to respond to a technical question from a high school student with a thorough explanation that does not overwhelm the questioner is a skill much needed by today's engineers (and easier though no less important than trying to help a journalist get it straight).

So if the reader is in agreement that there may indeed be value in having the engineering students make presentations in high school settings, then how could or should this be implemented? In this case the cliché is correct, "the devil is in the details". Having dispensed with the "why" by way of introduction, let me go on to explore the "who, when, where, how and what".

## II. Who

Perhaps more correctly, this should be the "Who"s, as there are several groups of people to be involved. The engineering faculty is the first "Who". Which faculty members should be trying to reach out to the high schools? Arguably the upper division undergraduate professors are probably the lead choice. It is these faculty that have engineering students who have the most "interesting stuff" to present to the high school students. This also identifies the second "Who", because it is the upper division students that are well advanced in their program that can best

answer questions. These students are capable and truly oriented towards engineering because of the natural effects of attrition on the less motivated students. It is the upper division students that have "the best stuff" coming out of laboratory experiments and design projects to present as artifacts for the high school students. The presentations that have been done by this author arise from incorporating a requirement of participation for all the senior design students and junior level machine design students. In both of these courses, as taught at The University of Texas at Tyler, there is a team based design project. The presence of such a project is a key requirement to establish involvement.

The third "Who" relates to the audience for the presentations. Which high school students are the most important to reach? In the "What" section there will come factors about who can be reached, but the preferred choice of student audiences is those who have shown aptitude in math and science. If at all possible the target audience should reach all the way into the junior high level. It is in these grades that necessary fundamental math courses such as algebra are commonly first encountered. If the program is not started early enough then it is hard to fit in all the desired courses.

The final "Who" is the hardest. This fourth "Who" relates to whom to contact in the high school to enlist aid in this cooperative effort. Because of the wide variety of high school administrative structures and scheduling schemes, only guidelines have been developed here. The challenge is to recognize who in the high school structure is the person or persons that will reap the most benefit and have the most motivation to follow through with what, for them, is a fairly modest commitment. First contact, depending on the structure of the school system, will most likely be with the Principal's or Superintendent's office. However the contact needs to be shifted into the math and science departments and may even start there. One of the most successful executions of this program came about through contact with the "department chair" of the science department of a moderately large high school. This chairwoman/teacher was most helpful, and when the college students could not be present on the right day in the high school schedule (an A-day, B-day type of schedule) she was able to arrange passes to get out of class for all the science oriented students to attend the presentation (a real motivator for high school students). Generally physics teachers most easily perceive themselves as the most apparent beneficiaries to the program, but a strong effort should be made to involve the math teachers, especially since most high school math classes have a substantial "applied math" orientation to them.

## III. When

The "When" of this effort is actually pretty easy. It is lamentable that "Engineers' Week" falls when it does when setting up a successful program of this sort. It would be advantageous if a presentation of this sort could be linked to "E-Week", but E-Week falls so early in the spring semester that, unless the courses are rearranged in a less than optimum manner, most of the best projects will have nothing at all to show at that time. The most successful time has proven to be the end of the spring semester. Nothing requires that design courses be scheduled in the spring, but many are, and they come to fruition at the end of the semester. Additionally this time is also optimum for the high schools. The end of the high school year is nearing, the students are really motivated by a break from the usual routine, and the some of the graduating seniors are still

trying to finalize their college goals, while many of the good high school juniors are finally starting to get serious about where they will go after high school.

## IV. Where

The "Where" is the most easily determined in a general sense, with many variations on the details. The most practical choice is to select a nearby high school. It is far easier to get the smaller number of college engineering students to the high school than vice versa. That being said, the "Where" comes down to "where in the high school?". Unless the program can be coordinated with a general "career day" (rarely will these fall at a convenient time), doing the presentation in some general access area of the high school is likely to be problematic and less than satisfactory. If a general access area is to be used, such as a cafeteria or atrium etc., pre-event advertising on the part of the high school math, science, and career guidance personnel will be crucial. The encouragement of students by faculty and guidance staff will be highly desirable in any event, but for this kind of presentation, it is critical.

The location that has worked best in this author's experience is to set up in a science area of the school and arrange to get the high school students to the presentation. Upper level high school students can get themselves to the presentation if they are given appropriate passes, but bringing in entire classes is better for lower level high school and junior high students. Setting up in an environment such as a physics laboratory has the advantage of providing the sort of space and facilities that are most useful. Electricity, water, drains, and large flat laboratory tables are often beneficial to some of the displays. Usually there are additional spaces where floor standing easels may be set up to facilitate poster displays.

## V. How and What

Various details of "How" to set up this program have already been covered, so the remaining "How" issues merge with the "What" in the area of actually putting on the event at the high school.

The first issue here is to be as self sufficient as possible. Avoid depending on any facilities at the high school as much as possible. For instance, if you need a projection screen and one is available at the location, still bring a back-up, even if you leave it in the car. High school faculty are fairly adept at getting what they need from the audio visual department, but they may not be well organized at getting what you need in a timely fashion. Also, be prepared for their equipment to be outdated and in poor repair. High school budgets are limited and the high school environment is rough on equipment. Bring your own computer if you need one for display, and protect it well, as high school students are notoriously careless. For instance, make sure that it is not near a table edge and cannot be pulled off by someone tripping on a cord.

As for what should be in the presentations: hardware, artifacts, mechanisms, mockups, animations and video displays! Poster presentations are generally best left as ancillary parts of the presentation. They can be effective if they contain easily seen, colorful, pictorial

information; and they can serve as an invaluable way to underscore the underlying mathematics in an engineering project. Professors and/or students can make a powerful presentation to the high school students with a computer display of math tools such as symbolic math processing software.

As to how the material is to be displayed to the high school students; presenting one project at a time to a whole classroom full of high school students is a recipe for boredom and disaster. It would also be far less than the best learning situation for the college students because of its limitation of interaction. Overwhelmingly more successful has been the approach of having all the displays set up around a room staffed with the engineering students who created them. Then turn the high school students loose to browse and ask questions. Not only does this allow the high school students to go where they are most interested and motivated, but it also allows the engineering students to repeat and refine their presentation time after time. When the high school students first arrive at the room they will generally be a bit hesitant and not sure what the routine is all about. The most effective manner of dealing with this is to have instructed the engineering students to be thinking more along the lines of a carnival side show barker than the usual presentations they have been doing. The professor should act as a greeter and set the tone with the same sort of approach. Once the process is started it will take on a life of its own. About two hours is about right for the presentation, but that represents actual presentation time. It will be necessary to arrange for set up and clean up time, as well as time for getting equipment into and out of the high school. Issues of getting equipment in and out needs to be addressed in advance, especially in light of the security protocols at many high schools these days.

Some details that will greatly smooth out the entire process should not be overlooked. Simple maps, to the high school and within the high school, should be provided to the engineering students, as many will be taking their own cars to the event. Parking should be pre-arranged and any security guards at the high school should be informed. Equipment and displays will likely need to be brought in by other than the main doors and this should be discussed with the high school security staff or supporting faculty. The engineering students should be instructed to "look professional" in their manner of dress and demeanor.

High school policy on providing engineering program information to their students may be surprising. Some localities have restrictions on visitors promoting one particular college in the absence of others, so any outright recruitment may be ok, or may be restricted or may not be permitted (not that this is a worry as the high school students very quickly figure out where all these neat and interesting engineering students came from).

If your engineering program has any minority recruitment programs, be sure to discuss this with any minority engineering students who are participating; many do not realize what a strong role model they will be. Minority high school students from lower socioeconomic circumstances tend to be greatly impressed and drawn to minority engineering students because they see them as having been successful in achieving desired goals, and these high school students want to know if they can do it too.

In the end, after the successful completion of such a presentation event, it is rewarding to see the guidance and motivation received by the high school students. There is simultaneously a sense

of accomplishment and confidence on the part of the engineering students, as they realize that they are regarded as expert in an area of interest to someone outside of engineering. There is also a sense of social fulfillment for the engineering students as they experience the high school students earnestly seeking their advice, guidance, and opinions about careers. The high school faculty has always been appreciative of the boost in interest that accrues to their classes after the presentations. The high school faculty often come away with a more realistic view of what application of science and math their students can look forward to if they go into engineering. (It is amazing how many people don't know what we engineers really do.) The profession, the college, and the program all benefit from bringing in more of the best minds, better motivated and better prepared than before. The surprising thing is, after once doing this sort of a presentation program, how easy it gets, and how little if any extra time it requires within the program and course.

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DONALD L. GODDARD PHD PE

Dr. Goddard teaches machine design and materials courses at The University of Texas, Tyler. His university teaching experience totals of 15 years, preceded by 13 years of industrial experience in nuclear power generation equipment design. His BS degree is from the University of Michigan School of Education, majoring in physics and minoring in math, social studies, and education, after which he taught physics and math in high school.