

Improving Engineering Guidance: Introduction to Engineering for High School Teachers and Counselors

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Abstract

This paper describes an innovative course designed to improve the effectiveness of high school mathematics and science teachers and college counselors in guiding their students toward engineering as a field of study and a career opportunity. The course titled "Introduction to Engineering for High School Teachers and Counselors" was first offered in Summer, 1997 and has been offered twice each year since then. A generous grant from the ARCO Foundation covered the cost of registration and materials and a modest stipend provided to participants. A total of 116 math and science teachers and college counselors completed the two-credit hour course during the first four offerings. Course evaluations indicated that the course was extremely well received and accomplished the stated objectives. This paper discusses the need for such a course, the course objectives, strategies for accomplishing the objectives, and the participants' feedback on the course. It is hoped that this paper will motivate other engineering schools to implement a similar course for teachers and counselors in their geographic area.

Introduction

Historically, student interest in engineering has been cyclical, based to great extent on the perceptions of employment opportunities. Over the past fifteen years, the number of students electing engineering as their college major has declined. For example, over this period the number of first year engineering majors in four-year institutions declined by almost 26 percent, from a peak of 115,303 in Fall, 1982 to 85,375 in Fall, 1996.¹

High school teachers and college counselors have the potential to significantly influence their students' choice of a college major. However, this potential does not appear to be realized for engineering. A 1974 study² listed the factors engineering seniors reported had influenced their choice of engineering as a field of study. Only five percent indicated talks with high school counselors had any value and only ten percent indicated talks with high school teachers were *very important*. These results are consistent with a later study³ that reported 59 percent of engineering students were first influenced to consider engineering as a career choice while in high school, but only four percent were influenced by high school counselors and thirteen percent by high school teachers.

In an effort to find out why high school teachers and counselors play such a small role in students' decisions to study engineering, the author conducted an anecdotal survey during visits to local area high schools over a several year period. The following was learned about mathematics and science teachers and college counselors:

- They do not feel they have adequate information and background to be effective in guiding their students toward engineering as a field of study and as a career choice.
- They view their lack of effectiveness in engineering guidance as a problem.
- They would welcome a solution to this problem.

The author's solution was to offer a modified version of Cal State L.A.'s *ENGR 100, Introduction to Engineering* course. The modified course was designed to accomplish three objectives:

1. Increase participants' awareness of engineering as a career opportunity for their students.
2. Orient participants to the engineering education process and to the profile of the student who would be prepared for that education.
3. Enhance participants' capability to teach their students strategies they need for success in high school and in engineering study.

Two primary challenges existed: 1) create adequate incentives to ensure that teachers and counselors would want to attend the course; and 2) develop and deliver a course that accomplished the stated objectives and would be well received by those who enrolled.

Publicity and Course Logistics

Considerable effort was made to design the course so that it would attract a large number of applicants. Careful consideration was given to offering the course at a convenient time and with an appealing format, ensuring that there was no cost to participants, and providing incentives and rewards for participation. It was decided to try two different formats—1) a three-day short course during the summer; and 2) a two-hour per week for eleven weeks regular quarter course during the academic year. A grant from the ARCO Foundation was obtained to cover the cost of participant's registration fees, all course materials, and a modest \$150 stipend to defray participants' incidental expenses. In addition, each participant received two units of university credit upon completion of the course. Unit credit is attractive to many teachers because completion of university level work is necessary for salary advancement.

Participants were recruited primarily through a direct mailing and, to a lesser extent, through personal contact during high school visitations. A database of 1,300 math and science teachers and college counselors at the School of Engineering and Technology's top 40 feeder high schools was created. A cover letter, brochure, and application form was mailed to this database approximately two-and-one-half months prior to the start of the course. For the second and subsequent offerings, a special mailing was sent to past participants asking them to encourage their colleagues to attend the course.

Applicants were notified of their acceptance within a short time following receipt of their application. A copy of the author's text *Studying Engineering: A Road Map to a Rewarding Career*⁴ was included with the acceptance letter along with a request that the book be read thoroughly prior to the start of the course. Two weeks before the start of the course, participants were sent the final course agenda and directions including information on parking.

The following table indicates the timing of publicity and applicant and participant response in relation to each of the two course formats.

Course Offered	Publicity Campaign	Format	Number Applied	Number Attended
Summer, 1997	Spring, 1997	3-day short course	33	29
Fall, 1997	Spring, 1997	2 hrs/wk for 11 weeks	19	14
Summer, 1998	Spring, 1998	3-day short course	39	33
Winter, 1999	Fall, 1998	2 hrs/wk for 11 weeks	45	43

As indicated, the publicity campaign for both the initial offering in Summer, 1997 and the second offering in Fall, 1997 was conducted during Spring, 1997. Publicizing the fall offering so far in advance resulted in a relatively low number enrolled for that course. Initially, it was felt that the low enrollment in the academic year offering was an indication that teachers and counselors preferred the summer short-course format. However, for the second cycle, when the academic year offering was moved to winter quarter with the publicity campaign conducted during fall quarter, the largest response to date was received.

Specific Sessions

Both for the three all-day short course and the regular quarter-long (two hours per week for eleven weeks) formats, the course included 13 major sessions, each lasting one to one-and-one-half hours, and three shorter presentations (20-30 minutes each). Shorter sessions included an orientation to the school's minority engineering program, a presentation on opportunities for high school students to take university courses, and a presentation on admissions procedures. The following are brief descriptions of each of the major sessions.

Session 1. What is Engineering? Rewards and Opportunities of Engineering as a Career.

A workshop was conducted to develop each participant's capability to give an articulate and motivating response to the question students often ask them: "What is engineering?" Standard definitions of "engineering" were covered. Participants were assigned the task of developing their presentation on *What is Engineering* and at the beginning of each course session a few minutes were devoted to hearing and critiquing them. In addition, the ten rewards and opportunities of engineering careers from Ref. 4 were presented and discussed.

1. Job satisfaction
2. Variety of opportunity
3. Challenging work
4. Intellectual development
5. Opportunity to benefit society
6. Financial security
7. Prestige
8. Professional work environment
9. Opportunities to understand how things work
10. Avenues for expressing your own creativity

Session 2. Engineering Disciplines.

A panel of three engineering professors (one each from CE, EE, and ME) made presentations about their discipline including why they chose it, what are the various subspecialties within it, and what type of career opportunities are available. A fourth panel member—an engineering professor from a local community college—discussed the benefits of doing the first two years of engineering study at a community college.

Session 3. What Do Engineers Do?

A panel of four practicing engineers from local corporations discussed why they chose engineering, what they do on the job, and how their engineering education prepared them for that work.

Session 4. Workshop: Using the Internet to Learn about Engineering.

An on-line workshop was conducted to teach participants how to learn about engineering on the Internet. Basic principles of using a search engine were reviewed. Participants were encouraged

to explore relevant web addresses including those of engineering professional societies (e.g., www.ieee.org, www.asme.org, etc.) and excellent engineering guidance sites such as:

www.asee.org/precollege/

www.engineeringnet.com

www.eweek.org

www.nae.edu/cwe

www.uh.edu/engines/

Session 5. Tour of Engineering Facilities.

Participants were divided into four groups and taken by tour guides to four locations on a rotating basis (20 minutes each) to see facilities and learn about activities in four areas: 1) engineering student design competitions (e.g. mini baja, micro mouse, concrete canoe, aero design project); 2) research projects including opportunities for undergraduate research; 3) computing facilities; and 4) manufacturing and automated manufacturing facilities.

Session 6. Engineering Case Study: The Solar Eagle Project.

A slide presentation emphasizing the design tradeoffs that must be made to produce a "world class" solar-electric vehicle was made by the faculty adviser of the Cal State L.A. Solar Eagle project. Technologies including composite fabrication, suspension design, solar panel production, battery performance, high efficiency electric motors, and on-board computer and telemetry systems were discussed. The challenges of putting together a student team to design, fabricate, test, and race a national championship solar car (Cal State L.A. Solar Eagle III won 1st place in a field of 36 entries in Sunrayce 97) were described. Participants then viewed the vehicle and discussed the project with team members.

Session 7: Overview of Engineering Education.

A presentation was made regarding engineering education in the United States. An overview of the history and current structure was included. ABET accreditation criteria and the categories of faculty, curriculum, facilities, students, resources, and administration were used as a framework for describing the engineering education system. Cal State L.A. graduation requirements in CE, EE, and ME were reviewed to provide some detail on the structure of an engineering curriculum. A discussion of what high school background would be desirable for engineering was held.

Session 8. A Student Perspective on Engineering Education.

A panel of Cal State L.A. upper division engineering students discussed why they chose engineering, their experience in engineering education, and their view toward their future career. Students were chosen so as to provide diversity both in terms of their high school record, choice of engineering discipline, and ethnicity and gender.

Session 9. Industry Outreach: Resources Available to High School Teachers and Students.

A panel of representatives from local industries discussed activities, programs, and resources their companies have to support high school teachers and students. Activities, programs, and resources described included field trips, speaker bureaus, Saturday programs, after school programs, web pages, summer employment (for both teachers and students), and educational materials.

Session 10. Success Strategies: Community Building and Goal Clarification

The importance of peer environment in student success was discussed. Methods of building learning communities was addressed. The importance of working with students to identify and clarify goals was also presented. Methods of strengthening students' commitment to a goal were discussed using the framework presented in the author's paper on this subject.⁵

Session 11. Success Strategies: Changing Student Attitudes and Behaviors

Areas in which students may have attitudes that are impeding their success were outlined. Methods of working with students to change those attitudes based on the author's paper on that subject⁶ were discussed. Behaviors appropriate to success in mathematics, science, and engineering study were presented. A five-step pedagogy for changing student behaviors based on the author's paper⁷ was discussed.

Session 12: Workshop: Hands on Classroom Activities

A workshop was conducted to provide teachers with "hands-on" activities they could take back to their classrooms. Activities included building a water propelled rocket and launch pad, setting up an assembly line to manufacture Plexiglas picture frames, and making a screwdriver handle by plastic injections and assembling it with a screwdriver blade.

Session 13. What Does Industry Want? Anticipating the Future.

A presentation was made on the type of attributes industry is looking for in new engineering graduates. The attributes sought under the new ABET Engineering Criteria 2000⁸ and the recent Society of Manufacturing Engineers report⁹ on competency gaps among newly hired engineering graduates were discussed. Trends in technology and in engineering employment for the future were also presented.

Course Evaluation

At the final meeting of each course offering, participants were invited to evaluate the course through both written evaluations and oral testimonials. The written responses to five questions were extremely positive.

1. What were the highlights of the course for you?

Evaluations indicated that participants enjoyed all of the sessions. They particularly liked the "hands-on" activities and the faculty, student, and practicing engineer panels. They also enjoyed the textbook, the tour of the engineering facilities, the workshop on how to use the Internet, and presentation on the Solar Eagle project. Some typical comments on course highlights were:

Listening to the intelligent, articulate, and personable professors, students, and engineers. You aren't just unsocial animals after all!!

First, the textbook, which is an outstanding resource. I am now prepared to steer my students toward your engineering program, as I see it is of very high quality. There is a deep and obvious dedication to the success of your students in your program. Very caring and professional.

I really enjoyed the three days. The water rocket, Solar Eagle, and making the picture frame. Also visiting the engineering lab and working on the Internet. All hands on activities. Also, the panels were interesting to listen to.

I particularly appreciated the panels that shared with us. I got a glimpse of "real" people in real jobs and roles. It is so easy for us as secondary educators to be completely out of touch with the "real" world.

I liked every class meeting because of the variety of the course: lectures, panels, visits to labs, hands-on computer lessons. I also appreciated the refreshments and snacks after a hard day's work. Thank you!

Everyone's enthusiasm to share information with school teachers. Friendliness and cooperation of everybody. Hospitality was excellent. Stipend and credit are very nice.

2. *How could we have made the course more appropriate for you? Should we eliminate any parts of the course?*

The participants generally felt that the course was very appropriate for them as indicated by comments like:

Well most all of it was appropriate for me.

Course was above and beyond my expectations.

Too bad the Biology Department, Math Department, Physics Department doesn't do this kind of course for high school teachers.

Everything was wonderful!. The organization was well thought out.

I like it just the way it was.

3. *What parts of the course could we improve on? Should we eliminate any parts of the course?*

The most frequent request was for more hands-on experiences they could use in their classrooms.

Give more practical examples that we could use in our classrooms. Math problem examples, lesson plans, etc.

I would like to see how we could incorporate engineering topics or projects into our classrooms.

More examples of engineering projects geared to high school science.

Possibly give more examples on how math can be used specifically in the field, and/or engineering examples we can use in our classroom that won't freak them out, but will make them see how useful math is in the field of engineering.

Evaluations of early offerings of the course provided excellent suggestions for improvement that were incorporated into later offerings including:

Spend less time reviewing the topics covered in the book.

Bring engineering students in to talk to us.

Arrange presentation from companies that have resources for high school students and teachers.

Make workshop on how to use the Internet to learn about engineering more fun.

Provide contact information for speakers who would be willing to come to my classes.

4. Give some specific examples of how you might incorporate parts of the course into your teaching and work with students.

By far, the most frequent response to this question referred to the "success strategies" covered in the course.

I can incorporate all the ideas on how to motivate students and the success strategies that were discussed.

I think I'll dedicate the first days of the school year to success strategies.

I loved the way in which you discussed goals. I will definitely use it!

I plan to work with students on how their attitudes and behaviors affect their achievement and how they can make positive changes to reach their goal.

I already, since reading your book, introduced goal setting and study skills at the beginning of my course.

I plan to use ideas in the book and course to get students to focus on what they want in their future. This is so important. Most don't get parental support to go to college and many kids think their future is so far away. I plan to spend time on goal setting, how to study, how to achieve goals, attitudes that work for you instead of against you.

Participants also indicated that they would be more effective in guiding students toward engineering.

I am also going to encourage students to go into engineering, now that I know what it is!

I feel I can better counsel my students regarding careers in engineering and programs in engineering.

Talk more specifically about engineering and all the various opportunities available. I might have an engineer speak to my classes next year.

I do research reports with my math students each year. I like to explore various careers to expose students to a broader range of careers. I feel I can better share the fields of engineering now.

I have a much better idea of what engineers do and how to prepare the students for majoring in engineering. I will be able to show them what courses they will take and in what sequence that they will be expected to take them.

I will be much more likely to direct students towards engineering, and above all, towards Cal State L.A. because of your sensitivity to their needs. I must admit I myself am attracted to the engineering program and my background is biology, genetics, and nutrition.

5. Please answer the following yes or no: "Would you recommend this course to a colleague?"

Responses were unanimously "Yes." Some expanded on their answer as follows.

Absolutely — The whole math dept, science dept, technology dept, and counseling dept.

Definitely! (I mean YES!!) I think every math and science teacher should take this! You should actually go to schools to do staff development on this. It's good stuff!

YES. I wish more of my colleagues had been here with me. Now I'll have to try and explain it to them myself! PS — You came really close to having me change careers! Be careful, or the educational system will lose a lot of their teachers, since you are doing such a good job of selling the engineering field.

Yes, it is refreshing to leave a workshop or conference motivated to return to the classroom.

YES!! They would be fools not to go! I've been to 3-day seminars before that have been mostly a waste of time. Your class was not like that!

YES!!! Especially our College Advisor. (I am going to steer my own daughter towards engineering!)

Summary

This paper discussed an innovative course titled "Introduction to Engineering for High School Teachers and Counselors." The course has proven to be an effective way to improve the engineering guidance skills of math and science teachers and college counselors. Through this course, teachers and counselors also learned how to work with their students on "success strategies" including goal setting and changing student attitudes and behaviors. A primary purpose of this paper is to motivate other engineering schools to conduct a similar course for teachers and counselors in their geographic area.

The results of the course have been disseminated through three articles in nationally distributed publications.^{10,11,12} In addition, a packet of detailed materials including copies of the proposal submitted to the ARCO Foundation, publicity materials, course agenda, course materials, and complete results of the course evaluation were distributed to all who requested them. This packet can be obtained by sending an e-mail to: rlandis@calstatela.edu.

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