BUILDING STUDENT COMMITMENT TO ENGINEERING

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INTRODUCTION

Studies of the graduation rates of underrepresented minority students in engineering indicate that Hispanic students are retained at about two-thirds the rate of all engineering students and that African American students are retained at about one-half the rate of all engineering students.[1] The primary response of engineering education to the differential success of underrepresented students has been to create minority engineering programs (MEPs) whose mission is to enhance the academic performance and increase the graduation rates of minority students.

Studies of the effectiveness of these programs have indicated that a well-designed MEP has the potential to bring about a doubling or even tripling of the graduation rates of participating students.[2] The current overall poor retention of minority students suggests that many existing MEPs are not operating up to this potential. The purpose of this paper is to discuss one key strategy for enhancing student success which undoubtedly needs strengthing in many MEPs—building student commitment to engineering.

In his classic book, *Leaving College*,[3] Vincent Tinto indicates eight primary reasons why students fail to complete their college education. The first of these is "intention" and the second is "commitment." According to Tinto,

> *"Whether they are phrased in terms of educational or occupational goals, individual intentions . . . are important predictors of the likelihood of degree completion."*

But having a clear goal is not enough. As Tinto indicates, the departure of many students

> *"is less a reflection of the lack of ability or even of intention than it is of an inability or unwillingness to apply their talents to the attainment of desired goals."*

This is particularly true in engineering study, one of the most difficult and demanding within the university. Only students with a strong commitment are likely to put in the time and effort required to succeed.

Unfortunately, many students enter engineering study without a clear picture of what engineering is or of the rewards and opportunities of an engineering career. Although the need to remedy this situation exists among all students, it may be even greater among traditionally underrepresented students. The differentially high attrition rate of minority engineering students is perhaps in itself evidence of a differential commitment to engineering study.

Although the need to strengthen traditionally underrepresented students' commitment to engineering study is critically important, those minority engineering program staff charged with this task may not be

focused on its importance and/or may lack the background and knowledge to accomplish this task. The purpose of this paper is to provide MEP staff with a framework for strengthening the commitment of their students to engineering

INTRODUCTION TO ENGINEERING COURSE

It should not be assumed that students will learn about engineering through the regular engineering curriculum. The freshman year engineering curriculum focuses almost entirely on mathematics, physics, and chemistry. If there are engineering courses in the freshman year, they are likely to be content-focused in areas such as computing, engineering graphics, design, or problem solving.

Even where engineering programs include traditional *Introduction to Engineering* courses as requirements in their curriculum, these courses may suffer from inattention on the part of engineering faculty and be candidates for the "Sleep 101" label described in a recent article in ASEE *PRISM*.[4]

Furthermore, MEP staff should resist the temptation to rely on one-on-one interactions to build their students' commitment to engineering study. Although motivating students can be personally rewarding, there is simply not time available to accomplish this important task through such a highly inefficient and impractical approach.

The task of building commitment to engineering can best be implemented in the context of an *Introduction to Engineering* freshman orientation course. This type of course has proven to be the cornerstone of an effective MEP.[5] It provides MEP staff with a highly efficient structure for accomplishing much of what they would be unable to accomplish in any other way.

Generally, an MEP freshman orientation course would addess five key themes:[6]

- Community building
- Professional development
- Academic development
- Personal development
- Orientation

Ideally, such a course would span the entire freshman year, meeting as an example for three hours a week for the fall term and one hour a week for the spring term for a total contact time of 50 to 60 hours. Building commitment to engineering would be a primary objective of the "Professional development" theme of the *Introduction to Engineering* course.

BEHAVIORAL AND ATTITUDINAL OBJECTIVES

The task of building student commitment to engineering involves changing student attitudes and changing student behaviors. The following are examples of attitudinal and behavioral objectives that would serve to increase student commitment to engineering:

- Students are highly motivated through a clear understanding of the rewards and opportunities success in engineering study will bring to their lives.
- Students can give an articulate response to the question: "What is engineering?"
- Students understand and know about the various academic disciplines and job functions of engineering.
- Students are aware of the various industry sectors (computer, aerospace electronic, utility, large constructors, oil, etc.) and of how engineers are utilized in each of these sectors.

- Students are aware of the benefits of pre-professional, engineering-related work experience (summer jobs, co-op, part-time jobs) and actively seek such positions.
- Students recognize the value of participating in student organizations, particularly those related to their academic discipline (ASCE, ASME, IEEE, AIChE, etc.) and become actively involved in those organizations.

BUILDING STUDENT COMMITMENT

Perhaps the first step is to convince students of the importance of having a strong commitment to engineering as a field of study and as a career goal. Students may not be in touch with the fact that they know very little about engineering and may not realize that their commitment to becoming an engineer is not sufficiently strong.

Ask the students in your *Introduction to Engineering* class: "Is success in engineering study the number one priority in your life?" You may be surprised to find that very few hands go up. The importance of commitment can be brought home by emphasizing that the most likely reason they will fail to complete their engineering program is that they will encounter some adversity and give up.

One of the primary reasons for the lack of strong commitment is that students know very little about engineering and very little about the rewards and opportunities of engineering careers. One way to uncover this is to have students in the *Introduction to Engineering* class respond extemporaneously to the question: "If your grandmother asked you what engineering is, what would you tell her?"

Help students understand that it is likely that they have a better understanding of most of the other respected professions available in the society (e.g. lawyer, doctor, accountant, minister, pharmacist, scientist, mathematician). Have a general discussion of why they have had so little exposure to engineering.

Teach students that learning about engineering is a lifelong process but it should begin now. Give them the perspective that they should take advantage of every opportunity to learn more about engineering. Have them brainstorm all the ideas of things they could do on their own initiative. The list might include:

- Go on field trips to industry.
- Talk to industry representatives at career day programs.
- Brouse the resource library in the career planning and placement center.
- Join the professional engineering society corresponding to their major.
- Read biographies of successful engineers.
- Get an engineering-related summer job.
- Read an *Introduction to Engineering* text.
- Pick a product (e.g., bicycle, car alarm, microwave oven) and research what role engineers play in its production.
- Interview a practicing engineer.
- Search the Internet for information on specific engineering disciplines.
- Write to an engineering society (IEEE, ASME, etc.) requesting information.

Assign some of these tasks as homework in your *Introduction to Engineering* course, but also encourage students to engage in them on their own initiative.

The following sections discuss strategies for accomplishing the six behavioral and attitudinal objectives outlined in the previous section. Supporting text material can be found in my new book *Studying Engineering: A Road Map to a Rewarding Career*[7] (particularly Chapters 2 and 5).

Rewards and Opportunities

Helping students understand that getting a good education (and specifically an engineering education) will significantly enhance the quality of their life throughout their entire life is an effective way to build commitment. Tell them what your education has meant to your life. When you have other speakers (dean, department chairs, industry representatives) ask them to spend some time giving their own personal testimonials.

Conduct a brainstorming exercise with your students in which they list all of the rewards and opportunities that will come through success in engineering study. Except for the idea that engineers are well paid, many students have given little or no thought to the many other rewards an engineering education will bring to them. Students should be able to come up with a list of thirty or forty items. My top ten list is:

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

Spend significant class time discussing each of the items on the list. What is it? Why would one value it? For example, what do we mean by "prestige"? Is *engineering* a prestigious profession? What benefits are there to choosing a prestigious profession? Have students pick their top five items and write a 500-750 word term paper on the topic "Why I Want to Be an Engineer" by personalizing their reasons for valuing each item they selected.

What is Engineering?

Students will also benefit from an under-standing of the "engineering process"—or put more directly, students should be able give an articulate response to the question they will be frequently asked *"What is engineering?"*

This task is "easier said than done." Try asking some of your engineering faculty what they would tell a high school student who asked them the same question. You may be surprised to find that many engineering faculty are not able to give an articulate response.

Certainly students should be able to quote the "textbook" definition of engineering:

> "***Engineering*** is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."[8]

But to get a real feel for the "essence" of engineering, time should be spent teaching students about the "engineering design process." Not only should students be aware that engineering is the process of producing a technical product to meet a specific need, they should understand the general steps in that process:

- identification of need or opportunity
- problem definition/design specifications
- data and information collection
- development of alternative designs
- evaluation of designs
- selection of optimal design
- implementation of optimal design

Student understanding of the "engineering process" can be greatly enhanced by illustrating it with examples or case studies. See if students can come up with products that they need but are not currently on the market or suggest some interesting ones: a device which would cause a VCR to skip the commercials while taping a TV show; a device to mark the forward progress of a football electronically; a fail-proof car alarm. Have them consider what steps would be required to produce a marketable product.

Simple hands-on projects can be illustrative. Have them design and build a solar hot dog cooker using tin foil as the reflector and have a contest to see which one cooks the "best" hot dog. We assign students in our *Introduction to Engineering* class the task of designing and fabricating something to display their name and bring it to class. After they have completed the task, we ask them who they designed it for. Did they design it so they could read their name? The instructor from the front of the room? All of the other students in the class? This exercise brings home the idea of "design specifications."

It may be a challenge to identify individuals to help students learn about engineering. Many engineering professors and practicing engineers are very effective at communicating specific parts of the engineering process. However, it is the exceptional person that has both the breadth of practical experience and the communication skills required to teach the "engineering process" to freshman students.

Academic Disciplines and Job Functions

The task of exposing students to the academic disciplines and job functions which categorize engineers is much easier. Students should get some exposure to the five traditional engineering disciplines—electrical, mechanical, civil, chemical, and industrial—and also be made aware that there are about twenty-five other non-traditional disciplines (e.g., aerospace, nuclear, petroleum, biomedical, environmental, etc.). Department chairs or faculty can be brought in as guest lecturers for this purpose. However, too much of this can be boring.

In my experience, students are "starved" for specific information on the engineering disciplines. Provide them with reading material such as brochures from the engineering professional societies (e.g., ASCE, ASME, IEEE) or material from *Introduction to Engineering* textbooks (e.g., Reference 7). Of most benefit are descriptions of the various subfields within each discipline.

As an example, the Institute of Electrical and Electronic Engineers (IEEE) is organized into 35 Technical Societies (aerospace and electronics systems, antennas and propagation, broadcast technology, circuits and systems, communications, consumer electronics . . . vehicular technology). The American

Society of Mechanical Engineers (ASME) is similarly organized into 36 Technical Divisions. A brief overview of each of these specialties not only gives students a deeper understanding of the discipline, but seeing the large number and variety of subspecialties can be very motivating.

Students should also learn about the different job functions that engineers perform. The most common are analysis, design, test, development, research, management, sales, consulting, and teaching. Guest speakers from industry can be brought in to talk about the various job functions. Alumni are ideal for this role. An assignment to interview a practicing engineer and write a written report on the experience can further enhance students' understanding of what engineers do.

Industry Sectors

Students should also learn about the various industry sectors and how they utilize engineers. Again the goal should be to strengthen students' commitment by making them aware of the enormous variety of opportunities that exist. One way to accomplish this is by exposing students to the Standard Industrial Classification (SIC) codes of the Federal government.[9] Every MEP should have a copy of this manual for students to peruse.

Under SIC, there are ninty-nine, two-digit SIC codes indicating major industry groups. For example, Major Group 38 is "Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks." Within Major Group 38, there are six industry subgroups, each having a three digit SIC code. For example, Industry Group No. 384 is "Surgical, Medical, and Dental Instruments and Supplies." And within Industry Group No. 384 there are five industries, each having a four digit SIC code. For example, Industry No. 3845 is "Electromedical and Electrotherapeutic Apparatus." Within Industry No. 3845, there is a long list of apparatus, each representing a collection of companies, most of which would use engineers.

One way to bring the vast range of opportunities to the attention of students is to have them choose one such product (e.g., lithotripters under SIC Code No. 3845) and research what companies are involved in the manufacture of this product and how they use engineers in their organization. Firsthand knowledge of how much activity there is in just one of literally tens of thousands of product areas can be very motivational to students. And they may very well develop an interest in an area which could lead them to a future employment opportunity.

Pre-professional Work Experience

Awareness of the opportunity to work in engineering-related jobs including summer jobs, co-op jobs, and part-time jobs can be motivating to freshman engineering students. Each of these three types of opportunities should be explained.

Through the *Introduction to Engineering* course, students should learn of the benefits of such jobs such as those listed below.

- Gain practical work experience.
- Earn money to support the cost of education.
- Gain important job search skills.
- Understand how academic work relates to the engineering work-world.
- Gain better understanding of engineering job functions.
- Gain "foot in the door" in terms of future permanent employment.

Students should be made aware that they will be evaluated based on three factors:

1. Level in the engineering curriculum
2. Academic performance
3. Personal qualifications

Although students have little control over their level in the curriculum, they should be made aware that they can substantially increase their chances of obtaining a pre-professional employment position by working on items #2 and #3, i.e., by building a strong academic record and by working to develop their personal qualifications.

Some time should be spent on teaching students how to go about a job search including resume writing and interviewing skills. Students should be encouraged to always have a current resume on hand. They should be taught about "informational interviews" as an effective strategy for building relationships that could lead to a job. An ideal course assignment would be to interview an engineering manager at a local company. The task of preparing for and conducting such an interview can be very educational and highly motivational.

The actual experience of working in an engineering-related job can play a major role in building student commitment. Encourage your students to aggressively seek these opportunities and to take the positive, assertive attitude that if anyone gets a job, it's going to be them.

Engineering Student Organizations

Finally, active participation in engineering student organizations can contribute to building students' commitment to engineering study. In fact, engineering student organizations are an effective vehicle for students to accomplish for themselves much of what you are trying to accomplish in your *Introduction to Engineering* course.

Typically engineering student organizations provide benefits to their members in five areas:

- Social interaction
- Professional development
- Academic development
- Personal development
- Service to the college and the community

[Note, in fact, that this list is the same as the five key themes of an MEP freshman orientation course presented on page 2 of this paper.]

Discuss these benefits with your students. What could be better than having your students interact socially with other engineering students rather that with students from other majors or friends from high school? Through participation, students will gain a sense of community and of belonging that can be highly motivational.

Tell your students about the important skills they will develop through participation in engineering student organizations. Emphasize that the leadership, organizational, and interpersonal skills they will gain will be extremely important to their success as an engineering professional. And let them know that the professional development activities of an engineering student organization such as speakers, field trips to

industry, and career day programs will complement what they are getting from your *Introduction to Engineering* course.

Make it easy for your students to join these organizations. Provide them with information about how to join and about upcoming meetings. You could even assign them the task of attending a meeting and writing a critique of what happened there. Invite leaders of these organizations to speak to the class to inform them about the activities of their organization. Make sure they emphasize why they got involved and what they got out of that involvement.

SUMMARY

Success in engineering study requires strong commitment. Many students lack this commitment and are therefore unwilling to make the personal sacrifice and put in all the hard work required. Minority Engineering Program (MEP) staff are in an ideal position to work with their students during the freshman year to build this commitment. However, they must first recognize the importance of doing so and seek a structure which provides sufficient contact time to accomplish this important task. An *Introduction to Engineering* course is an ideal structure for this purpose.

Through such a course, students can gain a clear picture of what success in engineering study will bring to their lives. They can learn about the "engineering design process," the various engineering academic disciplines, the various engineering job functions, and the various industry sectors and how they use engineers. Through this knowledge, they will become articulate in telling others about engineering. And they can learn about the opportunties for pre-professional employment in engineering and the benefits of such employment. Finally, they can learn about the value of participation in engineering student organizations and through such participation gain a sense of community and belonging.

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