Directions for Engineering and Technology Educators to Improve Program Enrollments

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Abstract - In addition to weak enrollments, engineering technology educational programs typically lack diversity among their student bodies [10]. In the Physics and Engineering undergraduate fields in the United States, women for instance, make up only 20% of the population, and in graduate programs, the gap is even wider than the 50:50 ratio one would expect [13]. Reduced enrollments and a lack of diversity create a challenge for engineering and technology program faculty members. Engineering and engineering technology educational program operators and faculty members are under pressure to find ways to increase enrollment and graduation rates in spite of budgetary restraints. The discussion that follows investigates the current status of engineering education in the United States, past trends of engineering education, and avenues of improvement for engineering educators as they pertain to two-year, and four-year engineering and engineering technology programs.

Keywords: student recruiting, student retention, diversity, STEM

INTRODUCTION

The number of graduates from engineering technology programs was declining from 1992 until 2005 [5]. In addition to weak enrollments, four-year engineering and two-year engineering technology educational programs typically lack diversity among their student bodies [10]. In the Physics and Engineering undergraduate fields in the United States, women for instance, make up only 20% of the population, and in graduate programs, the gap is even wider than the 50:50 ratio one would expect [13]. Reduced enrollments and a lack of diversity create a challenge for engineering and technology program faculties. Engineering and engineering technology educational program operators and faculty members are under pressure to find ways to increase enrollment and graduation rates in spite of budgetary restraints. The discussion that follows investigates the current status of engineering education in the United States, past trends of engineering education, and avenues of improvement for engineering educators. Throughout the discussion, an engineer refers to a graduate from a four-year engineering program, and a technologist refers to a graduate from a two-year or four-year engineering technology program.

DISCUSSION

Although recent examinations of student enrollment growth in four-year engineering and two-year engineering technology programs in the United States show some very minor recent improvement, engineering program

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enrollments have been on a general decline for the last decade [6]. While enrollment in engineering and technology programs has been flat for over twenty years with moderate recent increases [12], other curriculums, especially medical service programs, has increased substantially in proportion to population growth.

There are indications that current commercial and industrial demands for engineering workers are greater than the supply of engineers and technologists available [2] [3] [8]. Typical wages for two-year degreed engineering technologists ranges from only $18,000 to $35,000 for entry-level positions to $50,000 for experienced positions. The average wage during 2002 for technologists was approximately $35,800 in the United States [4]. The average wage for entry-level four-year engineering graduates was approximately $44,000 during 2002 [10] and would be expected to be even less this year with the current economic environment. Clearly, these wage figures do not reflect a shortage of engineers or technologists. The employment outlook is forecast to grow steadily for engineering and technology workers and recent increases in technology enrollment have been seen [5].An eighteen-year old student who completes college preparatory course work in the sciences will likely desire to attend college and obtain a professional position with greater growth potential than a two-year degree will allow. The average salaries cited above, especially for engineering technologists are unremarkable. Working conditions are sometimes difficult. The law of supply and demand applies to the supply of workers in a given field. As demand for a skill goes up, the number of workers with that skill will increase. Increase in demand is typically recognized by an increase in salary and benefits pertaining to the particular skill. The current shortage of and demand for health care workers shown in the want ad sections of any newspaper is an example of the law of supply and demand. Given the wage information above, one may not deduce there is great demand for technology workers or that there are too many since the wages rates for these workers do not appear to have risen dramatically in recent years. Educational institutions that offer programs in engineering or engineering technology must therefore anticipate a challenging task in recruiting students into their programs.

There has been a drop in spending in research and development (R&D) by Bell Labs [15] due to the technology and telecommunications industry meltdown. Bell Labs R&D spending has dropped from $3.54 billion in fiscal year 1999 to $2.31 billion in fiscal 2002. Researchers are starting to feel the pinch with diminished R&D and government spending. What impact does less R&D spending have on technical educators? The law of supply and demand, as discussed above, requires a decrease in the supply of technical workers with a decrease in the level of benefit derived from the field. Simply, if there are no high paying, secure jobs in technical occupations, then potential employees will seek jobs that are secure and high paying in other fields [15]. Stix [15] discusses the reduction of the number of R&D workers and the concern among Bell Labs' officers for the company's survival. Why would a young person want to enter a dying field?

The engineering job market is forecast to improve. It has been predicted that there will be more than 500,000 job openings in technical, associate degree positions by 2010 [11]. Coupled with the supposed current engineer and technologist shortage and a prediction of job growth in the field, one would expect a positive outlook for future enrollments at the nation's two-year and four-year technology colleges. But, during 2000, 80,000 students graduated from technology programs in the United States [9]. During this same period, another 90,000 technology workers in engineering and computer science were "imported" to fill job openings from other countries such as China and India. The worldwide economy may be damaging to homegrown engineers and their potential career attainment.

Engineering and Technology Educational Issues

With generally limited and diminishing budgets available, technology education program administrators are working to minimize the cost per student attending their institutions. Technical course-work generally costs more than general education course work due to specialized laboratories and equipment, higher paid faculty and smaller class sizes. Engineering and technology faculty members must develop courses that will fill classes with students, because empty seats cost money. Courses must be flexible, well organized, interesting, and pertinent to the field of study. The South Carolina Commission of Higher Education, for instance, evaluates associate degree programs on an annual basis in terms of enrollment, number of graduates, and graduate placement [12]. The Commission requires six graduates per year from each type of associate degree program offered at an institution in South Carolina. In the 2002 Commission Report, nearly all two year programs were on probation for lack of graduates were in engineering technology. This report also recommends that programs in engineering technology need to be

reviewed in terms of the type of curriculum they offer, the quantity of credit hours required for their completion and their ability to recruit and retain students.

The Technology Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc., Baltimore, Maryland ("ABET") requires an engineering technology or engineering student to demonstrate technical expertise in their field of engineering study. In addition, ABET requires two year graduates to complete a minimum number of semester hours of study and to be able to apply technical expertise to job fields such as specification, installation, fabrication, testing, operation, maintenance, sales, or documentation of basic engineering systems [1].

> ABET's Technology Criteria states: An engineering technology program must demonstrate that graduates have [1]:
>
> a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,
>
> b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology,
>
> c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
>
> d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
>
> e. an ability to function on teams,
>
> f. an ability to identify, analyze and solve technical problems,
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> g. an ability to communicate effectively,
>
> h. a recognition of the need for, and an ability to engage in lifelong learning,
>
> i. an ability to understand professional, ethical and social responsibilities,
>
> j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and
>
> k. a commitment to quality, timeliness and continuous improvement.

ABET's requirements are sometimes misunderstood by program faculties. The criteria suggest that all graduates from a program be perfect. This, naturally, is not the case. Job preparation for engineering and technology students may be thorough, but will not completely prepare any student for all employment situations that might arise. As a result of this misunderstanding by faculty and instructors, programs tend to be rigid and include much material not directly related to the field of study. Students may get bored with the material, drop out of their program, and enroll in other, more relevant content programs.

Another concern for engineering and technology educators is that high school and community college students seem intimidated by math and science subjects. John Shiber [14], Professor of Biological Sciences at Prestonsburg Community College, Prestonsburg, Kentucky, surveyed 1100 community college students and high school seniors with a questionnaire asking them to respond anonymously about the math or science course that they feared the most. He found that one-half of community college students, but few high school seniors, feared algebra. Nearly one-half of all students said they would be afraid to take calculus in college. Professor Shiber wonders if the prevailing sentiment about math in the United States is that only the superior, accelerated mind, not the average one, can understand math. Comprehending new math concepts requires motivation, discipline, and complete mastery of previous math concepts. Professor Shiber argues that teachers must take the time necessary to thoroughly teach, and make certain students understand each new math concept. Understanding of math concepts is the biggest issue to students' comprehension of engineering subjects and a possible issue for educators to address. Engineering and technology faculty should integrate their curriculum as much as possible with the math courses taken by students in their programs.

The future of engineering and engineering technology education in the United States may follow the same path that the United Kingdom has followed. The United Kingdom's (UK's) manufacturing base has moved to the Far East [7]. The government of the UK recognizes that the engineering profession has to re-position itself, both institutionally and practically to meet the challenge of achieving sustainable development within a transforming and rapidly globalizing economy. The UK recognizes the need for "knowledge" workers and technologists in

traditionally non-technical sectors of business such as the insurance industry. The United States may be undergoing the same changes in the manufacturing sector as the UK, but to a lesser degree.

Directions for educators

The most important issue for an engineering and/or engineering technology instructor is to ensure a high quality of instruction in the classroom. One should use classroom time wisely, use a variety of graphic aids, provide syllabi that are well thought out, and provide tests which are applicable to the material presented in class. An instructor should minimize "do nothing" days and restrict personal discussions with students to a minimum. The quality of instruction in the classroom should be the number one priority. Many teachers get consumed with their administrative responsibilities such as recruiting, reporting, and attending meetings. Instructors need to monitor usage of time in administrative functions to ensure class preparation is not affected.

Classroom facilities should be up to date and in good repair. Students prefer to attend classes in buildings that are well maintained. The faculties utilizing the facilities should inspect floors, interior and exterior walls, windows, and ceilings, and generate work orders for repairs and remodeling as needed. Ventilation should be functional and effective. Faculty members should promptly report extremely hot or cold classroom conditions to maintenance personnel and follow-up as needed.

Programs should be flexible to accommodate the needs of the students. Course offerings and times should be convenient for students. Technology faculties should ensure support courses are provided at convenient times for their students and should coordinate scheduling of general education curriculum with other academic departments. Course syllabi should include stringent learning objectives, but should not be intimidating.

Professors should be willing to take on coaching roles for their students. Advising students is a hated job duty for most instructors, but advisors in engineering and `technology programs should embrace advising roles to "get to know" their students. They should advise personally and diligently. Every student has different needs. Instructors should take time to build self-esteem into their students.

Faculties of engineering and technology programs should seek opportunities to integrate their curriculums whether they be high schools, two-year community colleges or four-year colleges. For example, Lehigh Carbon Community College in Schnecksville, Pennsylvania created a program for manufacturing technology students to flow from two years of high school through a two-year community college program through the final two years of a bachelor's degree [11]. The curriculum was geared to mechanical and electrical engineering, industrial automation robotics, and logistic technologies. This program is an example to follow. Any potential articulation must be consistent with the ABET's stated goals, especially the goal requiring a recognition of the need for, and an ability to engage in lifelong learning. The first step in an articulation process is for a faculty member to contact the department head of the targeted program and schedule a meeting to discuss the "fit" of the programs. The common elements of the programs should be determined and adjustments then made to the curriculums as needed and permitted.

Enrollments may also grow through diversity. There are few women in science and engineering programs. Life/work balance and family pressures are reasons usually cited for lack of women in engineering and technology programs. Culture is another reason given which makes technical disciplines unattractive to women. As discussed previously, in technical undergraduate fields, women make up only 20% of the population [13]. Some research indicates female participants in a male dominated program, such as a two-year engineering technology program, do not feel welcome to participate in study groups and social activities, causing higher dropout rates for females in technical programs [13]. If women are actively recruited and more actively retained, overall engineering and engineering technology program enrollments may improve.

Primarily men fill technical jobs, based on engineering undergraduate enrollment data [6]. Using this data, one might even state that primarily white men fill technical jobs in the United States. For women and minorities, this obviously is an issue. Black Americans make up less than five percent of engineering students [10]. For a business lacking racial and gender diversity, this again is obviously an issue, especially for businesses with a diverse customer base. Market share and revenue might be lost by such a non-diverse business. Outside the United States and other industrialized nations, women have significantly fewer occupational options due to cultural gender based

discrimination [10]. Once businesses in the United States recognize the need for women and minorities in their work forces, the law of supply and demand will address the lack of women in technical positions.

In addition to concerns pertaining to diversity, student advising and coaching, classroom instruction quality, and program articulations, educators must address financial considerations associated with their programs. The cost per student in engineering and technology programs tends to rise due to declining enrollment and decreasing class sizes. Distance learning is a means to counteract this trend. Distance learning uses the internet, videotapes, and closed circuit television to provide course work in ways which may differ from the traditional classroom to meet the time needs of their students. Engineering and engineering technology faculty members should seek assistance from administrators and other program faculties when possible to make improvements in their programs. Questions that must be addressed include, but are not limited to the following: How will tuition be handled? Which colleges have closed circuit television capabilities? Is there a person at each location willing to coordinate activities for students enrolled in distance courses?

Business and industry should be involved in any strategic planning in high schools, community colleges and universities. Business and education have common interests. Critical thinking skills, more general reasoning abilities, and social skills are areas of emphasis for educators as well as business. The current American culture and high standard of living will not be maintained without improvements in our educational system. As the world population grows, competition will only become more fierce in the world economic arena. Political demands by voters will force government officials to provide funding and other pertinent mechanisms for educational reform. American society will not tolerate standards of living substantially similar to those seen in Europe and the Far East. The American educational system will be corrected by the demands of voters.

CONCLUSION

There are several possible reasons for the failure of engineering and technology programs to grow as discussed. Manufacturing jobs seem to be less plentiful, less lucrative, and less secure than in the 1970s. Many students fear the mathematics required in engineering and engineering technology programs. Many engineering and technology programs may need to update their curriculums to meet student needs such as flexible class hours, accelerated, reduced length of programs, and articulations with two-year colleges. Most engineering technology programs also seem unable to compete with other job preparation programs such as nursing. There often is not an emphasis upon enrollment in engineering and technology programs by college presidents who view these programs as expensive compared to other non-technical course-work, especially math and English studies. With the current economic crisis, there is generally no shortage of students on college campuses.

For any state to maintain a competitive edge in recruiting businesses representing all occupational areas, not just manufacturing, there is a need for technical, "knowledge" workers. A program addressing the issues discussed previously, which include high quality, efficient classroom work, diversity, and/or distance learning could keep any state on track to best serve its citizens.

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