ENGINEERING 102: INTRODUCTION TO ENGINEERING OR "DO I REALLY WANT TO BE AN ENGINEER?"

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Introduction

The University of Michigan-Flint (UM-F) is a regional, nonresidential, primarily undergraduate campus. The mission of UM-F is to provide quality education for students residing within the ten-county region surrounding Flint. This past fall term about 6450 students registered at UM-F[1]. Over 94% of the students reside within the seven-counties immediately surrounding Flint. Of the undergraduate student population more than 66% are over the age of 22, and 29% are over 30 years of age; about 16% are minority; and over 60% are female. Compared to the parent campus in Ann Arbor, we are small. Most students at UM-F reside at home, either their own or their parents, are older than their peers at traditional colleges, and work at least twenty hours per week. Over 51% of the females are part-time students. Regular, tenure-track faculty or lecturers teach classes and laboratories. The emphasis for faculty is on quality education, with professional development sufficient to assure that faculty keep current in their fields.

The Engineering Science program is housed within the College of Arts and Sciences, although the program uses courses offered by the School of Management. The B.S. in Engineering Science degree program offers students the opportunity to obtain a quality engineering education at "home." Of those students indicating a concentration, about 280 students indicated a concentration in Engineering. About half of the students currently electing this program are more than twenty-two years of age, many are married, and some have children. Many of our students have elected to return to college after starting careers in the skilled trades field. Employment concerns within the auto industry are the main reasons that these students have returned to college.

Over 10% of the enrollment in the junior and senior engineering courses are women. These women began the program with a successful completion of the Introduction to Engineering course, where women have a success rate equivalent to that of the men. The focus of this article is these women, especially those that are neo-traditional students.

B.S. in Engineering Science

The present B.S. in Engineering Science program at UM-F evolved from several previous programs. In the late 1970's and early 1980's the program had only five engineering courses, and could be described as applied science. Part-time instructors from other colleges and from local industry provided the engineering instruction. Students elected courses such as Mechanics or Physical Chemistry along with majors in physics and chemistry. Actual engineering instruction was found only in such courses as Thermodynamics and Senior Design.

In the mid-1980's the program was completely redesigned and regular engineering faculty members were hired. The program content was revised to include courses in Materials Science, Manufacturing, Transport Phenomena, and Facilities Design. By the late 1980's laboratory courses were included in the curriculum, additional faculty members were hired, and the program content broadened to include Robotics, Circuit Analysis, Quality Control, and Production Analysis. In January, 1994, a revised B.S. in Engineering Science was approved by the College.

This revised program contains a strong mathematics and science preparation, as required for any engineering degree, including successful completion of two years of calculus, one year of chemistry, one year of calculus-based physics, English composition, and a computer language. The pre-requisite engineering courses include EGR 102, CAD, Statics, Mechanics of Deformable Solids, and the Science of Engineering Materials.

The Engineering program is designed to produce highly employable engineers. We train our engineers with all the skills necessary to work in today's industry. All UM-F engineering courses include design, team skills, written and oral presentations, and computer usage. Design projects, small at first, but increasing in complexity and detail, are included in every course from EGR 102 to the senior capstone courses. Each student is taught how to be a member of a team in each course, important in today's industry. Every student writes technical papers and gives oral presentations in each course. The use of computers for analysis, word processing, and drafting is required in each course. By incorporating these tools as the students progress though the program, the students graduating from our program know how to use these tools optimally.

The core required engineering courses at UM-F are significantly different from those in traditional engineering programs. The degree we offer is a B.S. in Engineering Science, not in mechanical, chemical, or electrical engineering. At other universities engineering science degree programs are typically comprised of courses chosen from traditional engineering disciplines. We do not have those traditional programs, and consequently have tailored the courses in our program to the needs of our graduates. The courses required of every graduate include Thermodynamics, Management Science, Transport Phenomena, and Kinematics and Mechanisms. Two of four laboratory courses [Materials, Manufacturing, Circuits, and Thermofluids] must be elected.

We have devised a series of tracks in the UM-F engineering program, each track tailored to meet a specific need in industry. A track consists of sixteen credits chosen from a group of courses focusing on a specific engineering application area. At present we offer four tracks: Controls and Robotics, Engineering Systems, Manufacturing and Materials, and Quality Control and Measurement. A given course may satisfy a requirement in more than one track. Courses may be chosen from other areas than engineering to satisfy the requirement. For example, Statistical Quality Control is taught in the School of Management by faculty with undergraduate engineering degrees. By using the expertise of faculty in other departments and programs, we can broaden the courses offered in the engineering program.

The capstone senior design courses conclude the student's engineering education. These courses offer the students the opportunity to apply the information acquired in prior courses, and construct what they design. We are often asked by local industry to

include one of their problems in our senior design courses. These "real-world" problems allow the student to interact with engineers in local industry, to give the report at local facilities, and to obtain the critical evaluation of practicing engineers.

The final element of our program is industrial practice. Every graduate of our program for the past six years has had some form of engineering experience in industry prior to graduation. Whether obtained through co-operative practice, industry-university contracts, or individual hiring, this experience is invaluable. Employers of our graduates comment that "they hit the ground running," they "know how to work in teams," and they "understand how to find information and then how to use it." Part of this success comes from our program; part from the energy and enthusiasm of the students.

Our success with an Engineering Science program is indicated by our graduates. All are currently employed in an engineering field.[2] Conversations with the employers of these students indicate that the graduates perform to the employer's standards and facilitate the kind of teamwork needed in today's industrial setting.

Engineering 102: Introduction to Engineering and Engineering Problem Solving

Students planning to concentrate in the B.S. in Engineering Science program enroll in EGR 102 in the fall term of their first year. This course has provided the answer to the question "Do I really want to be an engineer?" for over 400 students at UM-F since 1988.[3] Students must be committed to becoming engineers, since they must successfully complete the courses in chemistry, physics, and calculus prior to commencing the basic engineering courses.[4]

Students in EGR 102 are active. The role of the instructor includes keeping the groups organized and on schedule, guiding groups in teaming skills, providing background information, and giving encouragement to all. Students research and organize written and oral presentations. One presentation focuses on an engineering disaster such as the Tacoma Narrows Bridge, the Hyatt Regency Walkway, or the Interstate 95 bridge collapse.[5] Another project focuses on a specific engineering discipline, such as automotive, environmental, or biomedical engineering. Students are encouraged to contact local engineers, engineering societies, or professional engineering programs at local universities. Another project concerns the role of ethics in engineering practice. The course final exam is always a construction project, where the groups have to build, test, evaluate, improve, and then present their project. I assign the groups for each project except the one for engineering disciplines.

The engineering skills emphasized in later courses are started in EGR 102. All projects and presentations in EGR 102 are done in groups. One of the most important roles of the instructor in this course is to assist all students in learning how to make a group into a team. The first, and often most difficult, task is helping the students figure out how to communicate and cooperate. We use e-mail, memo writing, phone calls, and notes left on a specific bulletin board to encourage communication. Often just establishing the meeting time for a group requires hours of work, since most of these students work part- or full-time and their schedules do not overlap conveniently. Helping each student learn how to cooperate with the others is a major task for the instructor when the teams do meet. Dividing tasks, assigning responsibilities equitably, and following up are roles unfamiliar to many of these students. Encouraging, where appropriate, and pushing, where necessary, are typical

roles of an instructor. The success of a group when a team evolves is a wonder to behold.

Women in EGR 102

Women have comprised over 20% of the enrollment in EGR 102 since 1990. Table I gives the actual enrollment numbers for the beginning of the course for the years 1990 through 1993, and Table II gives the number of students that completed the course in those same years. More than 75% of the women complete the course successfully;[6] about the same fraction as that of men completing the course successfully.

Table I. Starting enrollments in EGR 102 by year.

Year	Male	Female	% Female
1990	44	16	26.7
1991	65	18	21.7
1992	58	14	19.4
1993	51	16	23.9
Total	218	64	22.7

Table II. Number of students completing EGR 102 by year.

Year	Male	Female	% Female
1990	36	12	25.0
1991	45	12	21.1
1992	49	11	18.3
1993	39	14	26.4
Total	169	49	22.5

Figure 1: The average age is 21.8 with a standard deviation of 6.1.

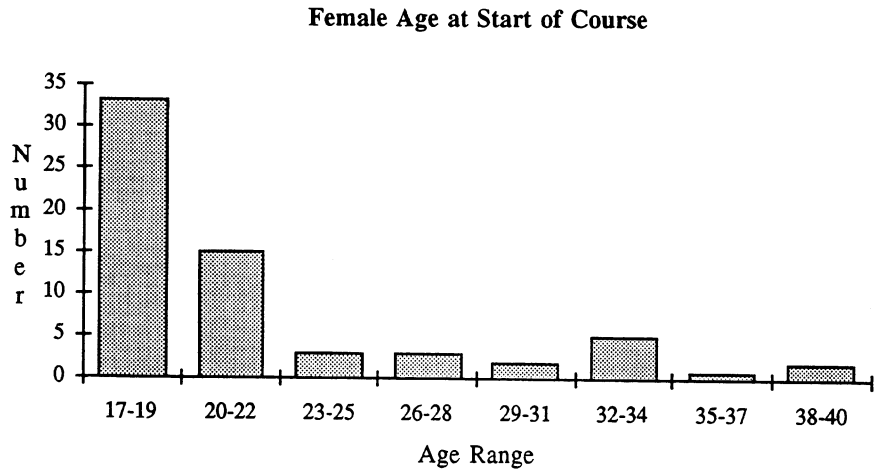

Figure 1 shows the age distribution for women in EGR 102. At the start of the course the youngest woman was 17 and the oldest was 40; compared with an age range of 17 to 25 for the male students. About half of the women are traditional, first-time-in-any-college students ranging in age from 17 to 19. Among the 19 to 21 age group are some women who have attended another college, usually a local community college, for one or more terms. About half of the women over 20 are first-time college

students. Many of these women went straight to work from high school, married, and had families. They have now chosen to return to college, for a wide variety of reasons. This group of women–older, experienced, mature, and with unusual time burdens–deserve special attention in engineering education.

Encouraging women in EGR 102 to become a part of a team is often difficult. The attitudes of the women range from passive [let the others do it] to dominant [I will take over]. Young women just out of high school tend to be passive, allowing the male group members to take over the leadership roles. They perform assigned tasks very well, but do not develop their own leadership skills. Older women, with families or job experience, tend to be dominant, asserting their right to the leadership role. They find it difficult to accept the ideas of the younger team members. Sometimes these older females appear to be treating the younger group members, whether male or female, as children. However, these older women students bring fresh perspectives to class discussions. One older woman compared stocking and distributing materials in a factory to operating her kitchen, a wonderful analogy. Balancing the attitudes, background experiences, and talents of the women in each team involves the instructor in some very unusual situations.

Women have been very successful in EGR 102 because each is encouraged to be successful. A+ grades are only given in this course to the one or more students with the highest total score in all the projects and presentations; otherwise + or - grades are not used. Since 1990 one or more women have earned A+ grades each term. Follow-up studies are conducted on all students in EGR 102 and a significant fraction of the women who are successful in this course continue in the B.S. in Engineering Science program. Over 65% of the women successfully completing EGR 102 are presently enrolled at UM-F, and over 50% are enrolled in the engineering program.

The neo-traditional women students in EGR 102 provide both a challenge and an opportunity. Those that choose to continue in engineering courses provide enrichment and maturity for their peers. Their positive attitude in the industrial positions held during college is welcomed by employers. These women have a role in the future of engineering.

Challenges for Engineering Educators

Encouraging older women to enter engineering is a challenge not yet acknowledged, much less met. Encouraging young women in the middle- and high-school years to consider science as a profession is popular. Encouraging women to return to college, whether after having a family or an aborted career, is also very popular. Encouraging these older women to pursue engineering is not popular. These women are often discouraged from considering engineering as a career.

There are two reasons given for discouraging older women to consider engineering. The first concerns the advisor's perception of engineering - math - math - math! If the woman has not been in school for a few years, placement in the lowest algebra class available is the usual result of taking the mathematics placement test. This does not have to occur, because often a simple refresher course is all that is needed. In fact, during the EGR 102 course a significant number of women who are taking the algebra course complain that they do not need it. After the first few weeks, their skills have been refreshed, and they are ready for trigonometry. Many successfully drop the algebra course, and sign up for the trigonometry course in the next term. Some even

sit in on the trigonometry course during the remainder of the term, take the math placement test, and successfully place into the first calculus course.

The second reason for not encouraging older women concerns the science requirement. Again the placement test for chemistry and physics usually results in the woman ending up in a one semester survey course. Depending on the time lapse between the science course taken in high school, the quality of that course, and recent science exposure, this placement is probably justified. At least the same complaints are not heard as about the math courses.

Given these prerequisites advisors often indicate to women that it will probably take five or more years to finish the engineering degree. That is true! What the advisor does not mention is that 1) most of our students take more than five years to complete this degree program[7], 2) women returning to school tend to do better in these courses, and subsequent courses, than traditional students because of their maturity and work skills, and 3) their life experiences will assist them to better adapt to college than traditional freshmen. All the women of age above 22 who have elected EGR 102 in the past four years, and who have chosen to continue in the engineering program, are successfully working toward their engineering degree.

So I challenge engineering educators to carefully examine the skills and talents afforded by older women in engineering. Unlike our colleagues in medical schools, we can afford to train these women. In fact, we cannot afford not to train them. They bring maturity, good work habits, and excellent organization skills to the profession. Their diligence, fresh perspectives, analysis and synthesis skills, and their creativity may afford engineering a new talent pool.

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[1]Data in this section is from the UM-F Fact Book, 1993-94.

[2]Two are patent attorneys. We count these two since their science degree is required for the practice of patent law.

[3]The author of this article has taught EGR 102 since 1990. The data presented is from these past four years.

[4]Approximately 20% of those electing EGR 102 over the past four years have answered "No" to this question.

[5]Students read To Engineer is Human: The Role of Failure in Successful Design, Henry Petroski, Vintage Books, New York, 1992.

[6]EGR 102 is graded on an A [4.0], B [3.0], C [2.0], N [no credit] system. Students who successfully complete the course are those that received an A, B, or C grade.

[7]From 1984 through 1993, the average time for the B.S. in Engineering Science degree program is 6.7 years.