

## Recruiting and Retaining Women in Engineering: A Kentucky Collaboration

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**Abstract** - According to the Engineering Workforce Commission, women received approximately 21% of the nation's B.S. degrees in engineering in 2000. If bio-related fields are omitted, the percentage drops well below 20%. Only modest improvement has been made in these statistics since, beginning in the mid-1980's, many U.S. engineering colleges focused attention on the issue of diversifying the engineering workforce. Current research indicates that eliminating the significant gender incongruity in engineering requires improvement in recruitment, retention, and advancement practices. In an effort to increase the number of B.S.-level women engineers in Kentucky, a partnership has been forged between Midway College and the University of Kentucky (UK). In this program, students enrolled in full-time study at Midway College may fulfill lower-division electrical engineering course requirements at UK while remaining predominately on the Midway campus. Students may earn an A.S. from Midway and a B.S. from UK in four years. Earning such a degree is becoming increasingly difficult in Kentucky, as smaller schools' offerings of pre-engineering curricula have diminished markedly over the past decade. Obstacles that have interfered with the recruitment, retention, and advancement of women in engineering are being countered in this innovative educational partnership. Despite dissimilar profiles, the two institutions embarking on this experiment possess notable similarities with respect to their commitment to gender diversity in engineering and their awareness of the need to increase the number of engineers in Kentucky.

**Index Terms** – Educational partnership, multi-institution collaboration, women in engineering.

### THE PROBLEM RECAST

According to Aristotle, "Each human being is bred with a unique set of potentials that yearn to be fulfilled as surely as the acorn yearns to become the oak within it." Mark Twain observed that "there is no security in life, only opportunity." In the field of engineering, the opportunity to harness a tremendous amount of professional potential is being lost because women are not being attracted to this field. Currently, less than 11% of working engineers are women; furthermore, only about 20% of the baccalaureate degrees in engineering are being awarded to women [1]. In the more specialized engineering disciplines, such as environmental engineering and some of the bioengineering, biomedical, and biotechnology fields, a small population of women is included; however, in the larger disciplines, such as mechanical and civil engineering, women still are woefully

underrepresented. In one recent report by the EWC [2], it was disclosed that fewer than 25% of B.S. engineering degrees were awarded to women in 2000 in these disciplines: aerospace, civil, computer, electrical, and mechanical.

The reasons for the significant gender incongruity in engineering may be divided into two main problematic categories. One is recruitment; the other is retention and advancement. Though this statement may appear to define a simple cause-effect relationship, in fact, the issues associated with recruitment, retention, and advancement of women in engineering are culturally complex.

Essentially, the obstacles to recruiting women into engineering spring from a four-pronged misconception affecting the image that young women have about engineers: (1) engineering is a man's profession, (2) engineering is an esoteric field, (3) engineers are "geeks," and (4) engineering is not perceived as a people-oriented profession. The first of these misconceptions—that engineering is a man's profession—is contingent upon the problem of recruiting women into the fields of math and science. This effort is hindered by one overriding enculturated attitude: girls are not adept at these subjects. Despite the fact that research indicates girls and boys perform equally well in these two disciplines, vestiges of the cultural myth that "girls don't do math, the language of science" provoke a self-fulfilling prophecy [3]. Studies confirm that this attitude cycles in the following way. Young women do not think they are competent in math and science because of a lack of encouragement from their teachers and peers; therefore, they are not interested in these areas. By eighth grade, they have already started to lose confidence in their abilities and any enthusiasm they might have had for these disciplines. In high school, usually their involvement in math and science has dwindled merely to fulfilling the basic requirements for graduation [4]. Then, because a college engineering curriculum relies heavily on the math-science foundation, women who have not studied these subjects in high school do not pursue them in higher education, and, consequently, are neither prepared for nor are recruited for engineering careers. As a result, the majority of newly recruited engineers are men; a fact that perpetuates the stereotype that engineering is a male-dominated field. Young women, then,

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are discouraged from aspiring to this profession and presumably strike it from their list of career options along with the motivation to study math and science, since the careers that rely on these disciplines seem to exclude women. Thus, the cycle of disinterest by girls and young women in math and science begins again, making them ill-equipped for recruitment into engineering, which continues to be identified primarily as a “man’s profession.”

Moreover, compounding this recruitment conundrum is the second prong of the four-pronged misconception affecting the image of engineers: engineering is an esoteric field—that is, what engineers do is understood only by a small group of privileged individuals. This misconception is fueled by the fact that many people do not understand what an engineer does. The American Association of Engineering Societies commissioned a Harris poll a few years ago, the results of which indicated that 61% of Americans have either little or no understanding of what an engineer does [1]. Therefore, they are unaware of the positive and exciting characteristics of this profession. Instead, for them, engineering becomes synonymous with vague and, perhaps, inconsequential duties performed by a nondescript, select group. Some of these uninformed people may be parents, and some even may be school guidance counselors. As a result, engineering is not being promoted as a career choice by parents for their children and by counselors for their students. Hence, this vital profession is drained of its appeal as a career option for both girls and boys. Boys, however, are more likely to revise the skewed view of engineering because the math and science track pursued by boys in high school invites them to investigate the field more fully. Girls, on the other hand, without a strong background in math and science and encouragement from their parents and teachers, have less impetus for exploring beyond their limited knowledge of what engineers do and so are more likely to reject this field as a viable career opportunity.

In addition to not being encouraged by parents and counselors to pursue the study of engineering, young women may even be *discouraged* by peers from entering this profession because, often, anyone studying math and science, the fundamental disciplines of engineering, is considered by adolescents to be a boring “geek” – after all, it is “not cool” to be smart in math. Furthering this unappealing image is the way in which engineers are depicted by the entertainment media. First of all, rarely does a television program or a movie incorporate a character who is an engineer. If an engineer does have a role in the story line, the engineer usually is a male--and not particularly glamorous or attractive at that. For instance, the engineer on the television show “Alien” was a reserved, bumbling character who sat in his corner and yet made the great contraptions that saved the heroine’s life; however, he certainly was not a person with whom anyone would want to go out to dinner afterwards. This unflattering image is one that neither girls nor boys would wish to emulate; however, because many boys are better prepared than girls for

pursuing studies in engineering, they are more likely to investigate the profession and to discover that the pejorative image of engineers is inaccurate, while girls are less likely to do so. Therefore, girls will continue to be swayed by the negative image and will ignore engineering as a career option.

Finally, young women do not think engineering is an attractive career because they do not see the “human side” of engineering and how engineers influence the quality of life. They do not understand the impact engineering has on our communities and the economy. More importantly, they do not think that engineers interact with people in their jobs – they believe engineers work alone in their cubicles just like the cartoon character, “Dilbert.” Fields such as biomedical engineering, chemical engineering, and environmental engineering are experiencing higher numbers of women engineers as they are perceived as benefiting humanity. It is this approach that Jamieson [5] has referred to as the “framing [of] the science in the social context.”

The ineffective recruitment of women into engineering, then, is a direct result of four misconceptions regarding the image of engineers and the field of engineering that dissuades women from entering this profession. The first misconception also accounts for the poor retention and advancement rate of women in engineering. This misconception, that engineering is a man’s profession, not only discourages women from studying engineering, thus ensuring that the profession remains predominantly male, but also influences an atmosphere of isolation and marginalization for the few women who do enter the field. Consequently, as students and as engineers in the workplace, women have few role models to inspire them to persevere and to advance in their profession. In addition, they lack access to informal networks that would help them move through their engineering careers. Finally, marginalized women engineers often encounter risk-averse managers who are afraid to put the women in challenging assignments. Thus, because women engineers have few role models, inadequate opportunities for mentoring, and minimal prospects for advancement, they frequently become disillusioned and leave the field, therefore further reducing their numbers in the profession and, consequently, discouraging young women from considering it as a career.

### THE MACRO-SOLUTION

This adverse trend can be reversed, however, by recalibrating the image of engineers. First, to correct the misconception that engineering is a man’s profession; more effective recruiting practices directed towards women must be devised and implemented. The initial step towards achieving this goal should occur at the middle school and high school levels by advising girls and young women to become actively engaged in the subjects of math and science and by applauding them for doing so. Already, some

progress has been made in this area by the Society of Women Engineers (SWE) and Women in Engineering Programs and Advocates Network (WEPAN), which are reaching out to female students on a one-on-one basis and on a one-on-small group basis in order to promote their interest in math and science and, also, to introduce them to women engineers. In addition, formal programs are being conducted by these organizations to educate teachers and school guidance counselors about the engineering profession in the hope that they, in turn, will encourage more girls to study math and science and to consider engineering as a career.

Extending these educational efforts to parents of students also is recommended. In this way, by educating teachers, school counselors, and parents about engineering, the misconception that it is an esoteric field also will be dispelled. The rationale for this approach is that, through proper education, the adults in the lives of girls will understand what engineers do, will recognize the importance of this work and how it benefits society, will show more enthusiasm for engineering as a career choice, and will direct the girls towards this profession.

A contingent benefit of this educational effort is that, in the process, the misconception that all engineers are boring “geeks” will be reassessed, thus alleviating the social pressures that divert young women from an engineering career track. In fact, improving the image of engineers has been a target of SWE. Their personal outreach efforts have been designed to educate young women of the following: (1) that engineers are women, (2) that they are attractive, (3) that they are having fun in their jobs, (4) that they are fulfilled in their careers, (5) that they are financially successful, and (6) that they have all the things an individual might want in a career.

Dispelling the misconceptions about engineers will induce more young women to study engineering. Thus, recruitment efforts will be more fruitful. As more women are recruited, the increased numbers in the field will minimize the feeling of isolation and marginalization that women engineers experience. Thus, they will have more female role models and mentors in the field, a stronger support network to encourage them to remain and advance in their careers, and more convincing advocacy for being awarded challenging assignments. With such enhancements in the workplace, the conditions influencing the retention and advancement of women engineers should be improved.

Ultimately, the solution to the problems currently interfering with the recruitment, retention, and advancement of women in engineering can be distilled into one directive: educate. This educational effort must occur on two levels. First, educators and the public must be instructed so that they may better advise girls about the need to study math and science; about the advantages of pursuing a career in a field such as engineering; and about what to do to prepare for it. Secondly, the girls and young women themselves should have the educative opportunity for direct contact with engineers--women engineers in particular--so that they may

be inspired to follow this professional path knowing that they are headed for an exciting, prestigious career, in which women can be successful, that will provide them with financial stability and personal fulfillment. This fulfillment comes from the knowledge that engineering is a service and a benefit to society. With these remedial measures, then, the ranks of engineering will be expanded with immeasurable talent as young girls and women are given the precious gift of “possibility.” In the words of Soren Kierkegaard: “If I were to wish for anything, I should not wish for wealth and power but for the passionate sense of potential—for the eye which, ever young and ardent, sees the possible. Pleasure disappoints; possibility never.” A great, virtually untapped, reservoir of possibility exists for the field of engineering; this possibility is the unrealized potential of women.

### ONE POSSIBLE APPROACH: MIDWAY COLLEGE AND UK COLLABORATION

The Kentucky Council on Postsecondary Education (CPE) has estimated that Kentucky must increase its undergraduate enrollment by 50%, from 160,000 to 240,000, by the year 2020, to bring the per capita enrollment in Kentucky into line with the projected average for the U.S. Engineering undergraduate enrollment in Kentucky, as a percentage of the entire undergraduate student body, is currently only 2.3%, while nationally, undergraduate enrollment in engineering represents approximately 3.0% of the whole. Assuming that engineering retains its current percentage of undergraduate enrollment nationally between now and 2020, Kentucky will have to increase its undergraduate engineering population by almost 100% to bring itself into line with national norms. To address this serious shortage of engineering production in Kentucky, the CPE in 2000 adopted the Statewide Strategy for the Expansion of Engineering Education [6]. The Strategy outlines an approach for effecting increases in existing undergraduate and graduate engineering programs in Lexington (UK) and Louisville (University of Louisville), but also called for the creation of collaborative programs involving multiple institutions. Part of this strategy involves the creation of cooperative programs (such as the UK engineering programs in Paducah, KY) and joint-degree programs (such as those hosted by Western Kentucky University in Bowling Green, KY) [7].

The Strategy also calls for engineering education in Kentucky to “eventually integrate secondary, baccalaureate, and post-baccalaureate programs. It will involve secondary schools, the Kentucky Community and Technical College System, the comprehensive universities, the research universities, *the independent colleges and universities* (emphasis added), and the Kentucky Commonwealth Virtual University.” The collaboration between Midway College and UK serves as a model for other institutions in the Commonwealth. The immediate interest is in attracting and

retaining women into engineering studies at UK, first with a focus on electrical engineering.

While great strides have been made at UK in terms of women in engineering, UK engineering enrollment of women continues to lag the nation, presumably largely because of the dearth of engineering majors that tend to attract women. The most populous majors in UK engineering in Fall 2003, with the percentage of women enrolled, are, in order of student population, Mechanical Engineering (7.65%), Computer Science (11.50%), Civil

Engineering (15.05%), and Electrical Engineering (9.93%). These four majors account for 82.3% of the College's total undergraduate enrollment, with the remaining 17.7% in the following majors: Chemical Engineering, Biosystems and Agricultural Engineering, Mining Engineering, and Materials Engineering. The College total female undergraduate population is 280 out of a total student body of 1966, or 14.25%. Historic enrollment trends at UK are provided in Figures 1 and 2.

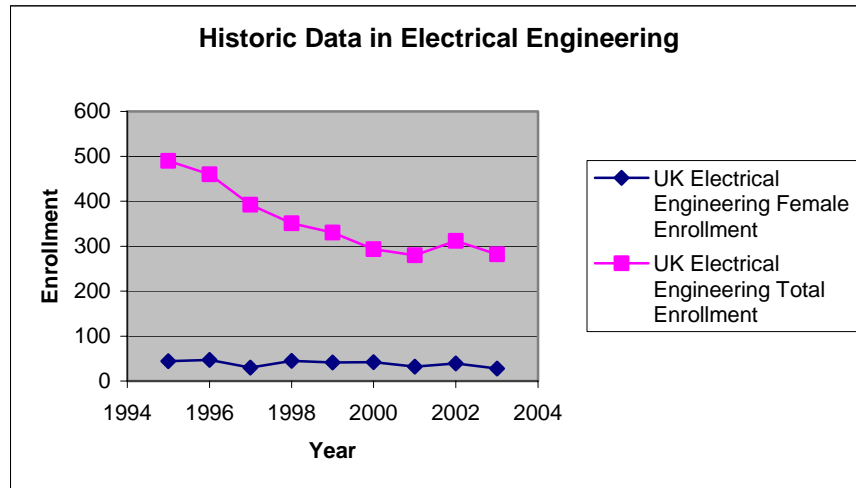


FIGURE 1 Enrollment trend in UK Electrical Engineering.

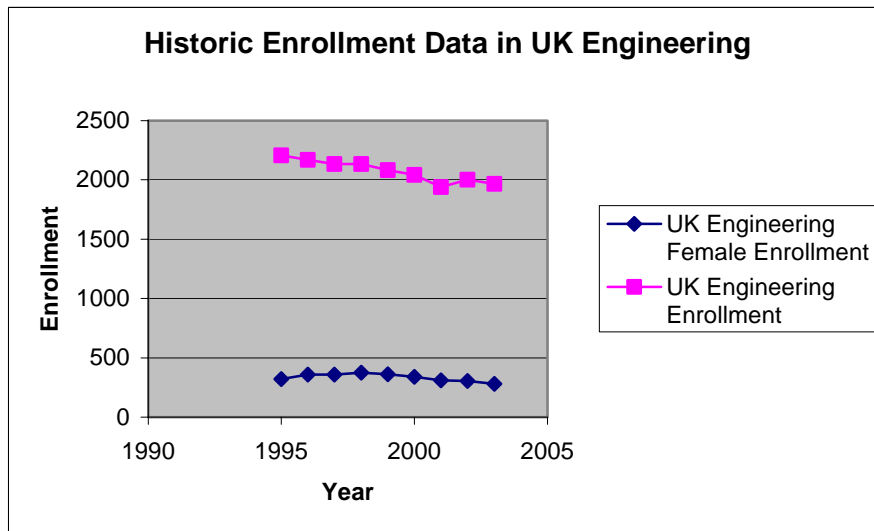


FIGURE 2 Enrollment trend in UK Engineering

Midway College is a small (1150 enrollment), independent, liberal arts college offering two- and four-year degrees. The student body is a blend of traditional-age students and women returning to school as adults. Working women and men enrolled in Midway's School for Career Development evening and extension programs complete the student profile. Midway is located in the heart of Central Kentucky's Bluegrass Region and is a 30-minute drive from the UK main campus (35,000 enrollment). As Kentucky's only college for women, Midway has a long-standing reputation of strength in professionally-oriented liberal arts education. Midway offers baccalaureate degrees in fourteen disciplines, including mathematics, biology, chemistry, and environmental science. Within the past five years, motivated by a lead gift of \$2M for the construction of the \$6.5M Anne Hart Raymond Mathematics, Science and Technology Center on the Midway campus, Midway has embarked on an aggressive campaign to increase its enrollment in mathematics and pre-engineering. The lead author was hired as the institution's first Chair of its Math/Science/Engineering Division in 2002.

The UK/Midway collaboration in engineering is but one of a number of initiatives between the two institutions [8]:

- Since 1998, UK has hosted Midway College's successful B.A. degree program in Organizational Management on the Lexington Community College campus (which is a part of the UK system).
- Midway College faculty have partnered with UK researchers on the effects of using industrial hemp as a food additive for horses.
- Midway College has offered to partner with UK in housing some of our students in Midway and in offering UK coursework to these students on the Midway campus.
- Midway's Women's Enterprise Institute works in collaboration with the Kentucky Small Business Development Center at the UK Gatton College of Business and Economics.

In addition, A recent query in UK's Student Information System revealed a total of over 300 UK equivalencies with either current or past Midway courses, which provided a firm foundation for the activities leading up to the construction of the dual-degree program detailed herein.

Beginning January 2003, UK and Midway College representatives began constructing a detailed articulation agreement (available upon request) that will enable Midway students to smoothly transition from Midway to the BSEE program at UK. In this program, third-semester Midway students will take EE 101 (EE Professions Seminar) and EE 211 (Circuits I) on the Lexington campus. Should sufficient enrollment be achieved (6-8 students), the UK course can be offered on the Midway campus by an itinerant UK faculty member. The dual-degree program calls for students to fulfill 62 credit hours through Midway, yet simultaneously complete 13 credit hours at (or through) UK, making a

genuine 2 + 2 program a reality. The transferring student would then have completed 75 credit hours of a 130 credit-hour program before entering her junior year. Under current investigation by Midway College is the possibility of a 3 + 2 permutation, through which careful selection of mathematics electives and supportive electives at UK may enable the participating student to earn a B.A. in Mathematics from Midway College while fulfilling UK degree requirements for the B.S. in Electrical Engineering. It is thought that there is sufficient opportunity for this with a minimum number of total credits beyond 130, although this is yet to be finalized.

Electrical engineering was the targeted major for several pragmatic reasons: (1) the existing strength within Midway College in areas of mathematics and computer science, (2) the relative laboratory independency of the EE pre-engineering curriculum as compared with other engineering majors, (3) the existing support for this initiative within the UK EE faculty and administration, (4) the capacity that exists in the UK EE program, wrought by current enrollment trends, and (5) the plan for UK addition of an undergraduate program in Computer Engineering (tentative Fall 2004 implementation date).

### CURRENT STATUS

Although much work has already been accomplished, there remain a limited number of unresolved issues, some that require Midway initiative and others that require action by UK or by both institutions:

- Final UK approval of two Midway calculus-based physics laboratories.
- Continued joint efforts to find a suitable equivalency to UK's ENG 102. If unresolved, students would need to complete ENG 102 either at UK or some other institution with which UK has an equivalent.
- Discussions at the CAO level regarding how to handle admission, registration, and tuition and fees for dual-registered students. A workable model has been agreed upon in principle between the second author and Midway's Vice President for Academic Affairs, pending approval of the respective institution's leadership. Under this model, Midway students would apply and register as a part-time UK student, with fees deferred until after the final date for student refund, after which Midway would transfer the equivalent of tuition and fees to UK. (At present, UK's resident tuition is approximately 50% of Midway's and its non-resident tuition is approximately 120% of Midway's.)
- Not an insignificant issue is one of student parking. Since it is imperative that students be able to drive to Lexington, find a place to park, and get to class in no more than one hour (this to sterilize a minimum number of course-scheduling hours on the Midway

campus), arranging parking for these commuting students is very important.

### CONCLUSION

The UK leadership has placed strong emphasis on the University's ability to help shape Kentucky's economy. It is hoped that this partnership, which conforms to the spirit and intent of Kentucky's statewide strategy for expansion of engineering, will serve to not only increase the number of engineering graduates in Kentucky but will also work toward increasing the diversity of the engineering graduates by encouraging women to enter the electrical engineering profession. This collaborative effort represents a bold experiment in Kentucky higher education, in which two disparate academic institutions have combined resources for achievement of a goal of increased diversity in engineering education in the Commonwealth. Neither institution has wavered from this commitment, providing its respective representatives with the infrastructure, staff, operating budget, and administrative support to be successful in its efforts. Furthermore, the partnership should serve as a model for collaborative efforts among other Kentucky colleges and universities [8].

Finally, as saliently put by William A Wulf, "Every time an engineering problem is approached with a pale, male design team, it may be difficult to find the best solution, understand the design options, or know how to evaluate the constraints." [9]. Diversity, then, is not so much about quantity but about quality. That said, it is apparent that underrepresented groups, including females, are increasingly not choosing engineering as a career and that the changing demographics of the U.S. will make the situation worse unless more underrepresented groups choose engineering [10]. The program described here attempts to counteract these trends on a regional and statewide basis.

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